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# Abandoned Mine Land Inventory and Hazard Evaluation Handbook



U.S. Department of the Interior
Bureau of Mines

September 1993

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# ABANDONED MINE LAND INVENTORY

# AND

# HAZARD EVALUATION HANDBOOK

By

Staff, U.S. Bureau of Mines

September 1993

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**DRAFT**

## FOREWORD

The U.S. Bureau of Mines produced this handbook in response to the increased concern by many groups, including land managing agencies, about the environmental and physical hazards and legal liabilities of abandoned mines. It sets forth guidance for the development of an abandoned mine land (AML) inventory and the subsequent investigation and evaluation of the environmental and physical hazards present on such lands. It is designed for use by land management and other agencies that are subject to regulations governing the mitigation of environmental and public safety hazards that exist on AML within their jurisdiction but who may be unfamiliar with mining and mineral processing.

Mines, mills, and smelters may be divided into two groups: operating (those with production) and non-operating (those without production). This manual addresses only the non-operating mines, mills, and smelters. The term "abandoned mine land" is used herein as a generic term without specific intent or implication to any legal or political connotation on a State or national level.

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## ABBREVIATIONS USED IN THIS HANDBOOK

### Units of Measure

| | | | |
|---|---|---|---|
| cm | centimeter | mg/L | milligram per liter |
| cm/yr | centimeter per year | m | meter |
| cps | count per second | min | minute |
| ft | foot | mt | metric ton |
| gpm | gallon per minute | pct | percent |
| in | inch | sec | second |
| $in^3/gal$ | cubic inch per gallon | ° | degree of arc |
| km | kilometer | | |

### Acronyms

| | |
|---|---|
| AML | abandoned mine land(s) |
| ANFO | ammonium nitrate and fuel oil |
| BLM | (U.S.) Bureau of Land Management |
| CERCLA | Comprehensive Environmental Response Compensation Liability Act |
| DMEA | Defense Minerals Exploration Administration |
| DOC | (U.S.) Department of Commerce |
| EPA | (U.S.) Environmental Protection Agency |
| GPS | global positioning system |
| IC | Information Circular, U.S. Bureau of Mines |
| IRS | Internal Revenue Service |
| MAS | Minerals Availability System, U.S. Bureau of Mines |
| MILS | Mineral Industry Location System, U.S. Bureau of Mines |
| MLA | Mineral Land Assessment, U.S. Bureau of Mines |
| MPF | Mineral Property Files |
| MRDS | Mineral Resource Data System, U.S. Geological Survey |
| MSHA | Mine Safety and Health Administration, U.S. Department of Labor |
| NPL | National Priorities List |
| OFR | open file report |
| PLS | public land survey |
| RI | Report of Investigation, U.S. Bureau of Mines |
| TDS | total dissolved solids |
| USBM | U.S. Bureau of Mines, Department of the Interior |
| USGS | U.S. Geological Survey, Department of the Interior |
| UTM | universal transverse mercator |
| WMR | War Minerals Report |

# ABANDONED MINE LAND INVENTORY AND HAZARD EVALUATION HANDBOOK

By

Staff, U.S. Bureau of Mines

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## ABSTRACT

The purpose of an abandoned mine land (AML) inventory and investigation is to identify and assess AML sites and associated hazards. This U.S. Bureau of Mines (USBM) handbook describes how to develop and conduct such an inventory and assessment using a four-step process. The focus is on hardrock sites. In the early part of the handbook and in Step I, specific things to consider during a reconnaissance of an AML site are described, as are the data required to adequately assess a site. In Step II, the environmental and physical hazards at each site on the AML inventory are initially assessed and ranked according to potential risk to the environment and human health. Following a site investigation involving the use of a standard data form (Step III), each site on the AML inventory is assigned a priority ranking (Step IV) on which to base site characterization or hazard mitigation.

Major hazards that may be present on abandoned mine lands are discussed in two broad categories: environmental and physical hazards. Environmental hazards include toxic substances, heavy metals, polychlorinated biphenyls, acids, petroleum products, asbestos, radioactive materials, sedimentation, and dust. Physical hazards include abandoned explosives, unstable structures, mechanical equipment, scrap materials, underground workings, open pits, highwalls, ditches, subsidence, waste piles, and impoundments.

## INTRODUCTION

Government agencies, because of recently enacted regulations, face a rapidly expanding, costly liability for the cleanup of hazardous sites. This is particularly true for public lands containing abandoned mining and milling sites. The Environmental Protection Agency (EPA), in a 1985 report to Congress, estimated the total volume of existing mine wastes to be more than 45 billion mt. A 1991 report prepared for the Western Governors' Association indicates the total number of sites to be hundreds of thousands and the potential cost of remediation to be billions of dollars.

U.S. Bureau of Mines (USBM) records show that at least 200,000 mining-related sites, most abandoned or inactive, exist nationally. The obviously hazardous sites, especially those proximal to urban areas, have been targeted under the Comprehensive Environmental Response Compensation, and Liability Act of 1980 (CERCLA or Superfund). Of the more than 1,200 sites on the National Priorities List (NPL), 59 (4.9 pct) are directly related to mining. However, of the remaining mine sites, those that deserve priority attention and, just as important, those which can be ignored, are largely unidentified. Most of these sites are in rural areas, often on or surrounded by public lands and thus the responsibility of Federal land-management agencies. In the absence of a clear understanding of the scope and severity of hazards associated with inactive and abandoned mine lands (AML), the public and Government agencies are very concerned about the true risks posed by these lands. This concern, and regulatory mandates, have prompted a need for detailed inventories of AML and analyses of AML hazards.

The purpose of this handbook, then, is to facilitate standardized, consistent AML inventories. It is probable that there will be a desire to complete an inventory of all sites in a short timeframe. It is also probable that many investigators will not have an extensive mineral and environmental science background. This handbook provides such an investigator with sufficient knowledge and guidance to be able to conduct an effective, efficient AML inventory and evaluate the environmental and public safety hazards present. It is not intended to be an in-depth source of information; an extensive bibliography is in appendix J. Also, because coal mines have already been inventoried according to Office of Surface Mining directives and procedures, the handbook is focused on hardrock AML sites.

The AML inventory and evaluation process presented herein is designed to efficiently and accurately identify priority sites. It entails four steps: Step I–development of an AML database/list of sites using files, literature, databases, and other sources; Step II-selection of sites for 1/2-day field investigations; Step III- field investigation of selected sites using a standardized data reporting form; Step IV–identification of sites requiring future action. While consistency among inventories is highly desirable, investigators can modify, augment, or supplement these steps to suit their own requirements, or incorporate portions in an already established system.

If AML investigators or members of their agency need additional copies of this handbook or assistance in assessing either physical or environmental hazards, contact the U.S. Bureau of Mines, Western Field Operations Center, Spokane, WA (509-353-2700).

## MINERAL INDUSTRY OVERVIEW

A variety of mineral commodities and mining-milling situations may be encountered in an AML inventory-evaluation program. For those unfamiliar with mining or mineral processing, industry practices

are summarized in this section (fig. 1), a glossary of commonly used terms is presented in appendix A, and a detailed discussion of four selected processing methods is included in appendix B.

Mineral commodities can be grouped into three categories: metallic minerals, nonmetallic (industrial) minerals, and solid energy fuels. Metallic minerals, commonly called "ores," consist of the precious metals (gold, silver), base metal sulfides (sulfides of copper, lead, zinc), and oxides of major metals (aluminum, iron, nickel). Nonmetallic minerals consist of minerals such as asbestos, calcite, dolomite, gypsum, and quartz that are not processed for the metals they contain. Rather, their value lies in their chemical and physical properties. Solid energy fuels include coal, tar sands, and uranium.

Mineral exploration is carried out by individual prospectors who hope to make a discovery they can develop or sell to a mining company, and by the exploration departments of small and large mining companies. Mineral exploration usually begins with an idea and follows a detailed plan. If surface information indicates a mineral deposit is present, a drilling program may be initiated to determine the shape, size, and grade of the deposit.

There are two basic ways in which minerals are mined--surface and underground. The selection of a mining method depends on the nature and location of the deposit and cost considerations.

Surface or open pit mining is used for large, near-surface deposits which have a low commodity value per unit of volume. Rock is drilled, blasted, loaded into trucks, and hauled to a facility where it is crushed and ground to a uniform size.

Underground mining methods are used when mineralized rock occurs deep beneath the Earth's surface. To reach the ore body, remove ore and waste, and provide ventilation, miners must excavate either a vertical shaft, a horizontal adit, or an inclined passageway. Within the ore deposit, horizontal passages called "drifts" and "crosscuts" are developed on several levels to access mining areas called "stopes" (fig. 2). Blasted rock is hauled away from the stopes by trains, loaders, or trucks that may take it directly to the surface or transport it to a shaft where it is hoisted to the surface and sent to a crushing facility.

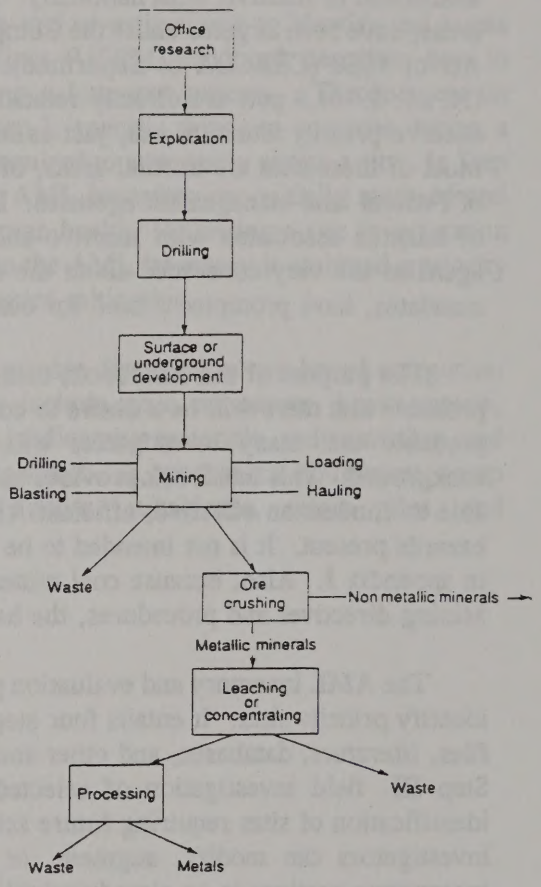



**Figure 1.–Generalized mineral industry flowsheet.**

Nonmetallic minerals and solid energy fuels are, usually after crushing and cleaning, used as is in commodity-specific plants. At metal mines, crushed ore is treated by heap leaching or concentrating, depending on its grade. See appendix B for a discussion of ore leaching and concentration.

Ore to be leached is stacked on an impervious pad in large piles composed of many layers of crushed ore. Chemical solutions sprinkled on the ore percolate down, dissolving the metallic minerals. The metal-bearing solution is collected at the base of the pile and pumped to a processing plant where the metal is recovered from solution.

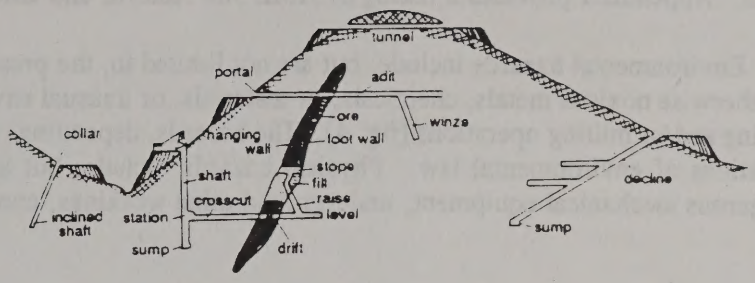



**Figure 2.–Cross section of underground mine.**

Nonleach ore is hauled to a mill where the metallic minerals are separated from the nonmetallic minerals and from each other by gravity or flotation methods. Flotation works by bubbling air through a mixture of crushed ore, water, and certain chemicals. Metallic minerals selectively attach themselves to the bubbles, float to the surface, and are skimmed off and dried. Mineral processing plants (mills) are not always located next to mines; they can be several kilometers apart. See appendix B for a discussion of mineral flotation.

Mineral concentrate produced by gravity or flotation is shipped to a processing plant where it is converted to metal in the form of bars, ingots, sheets, or wire. These metals then are used in the manufacture of finished products such as automobiles.

Waste materials left over from mining, crushing, leaching, concentrating, and processing are dumped or pumped in large piles or impoundments, or are recycled.

Abandoned mines (fig. 3), mills, waste dumps, tailings ponds, leach piles, and other related features can pose a threat to human health and the environment. The objective of an AML inventory is to document the presence or absence of physical and chemical hazards and to decide on future actions.

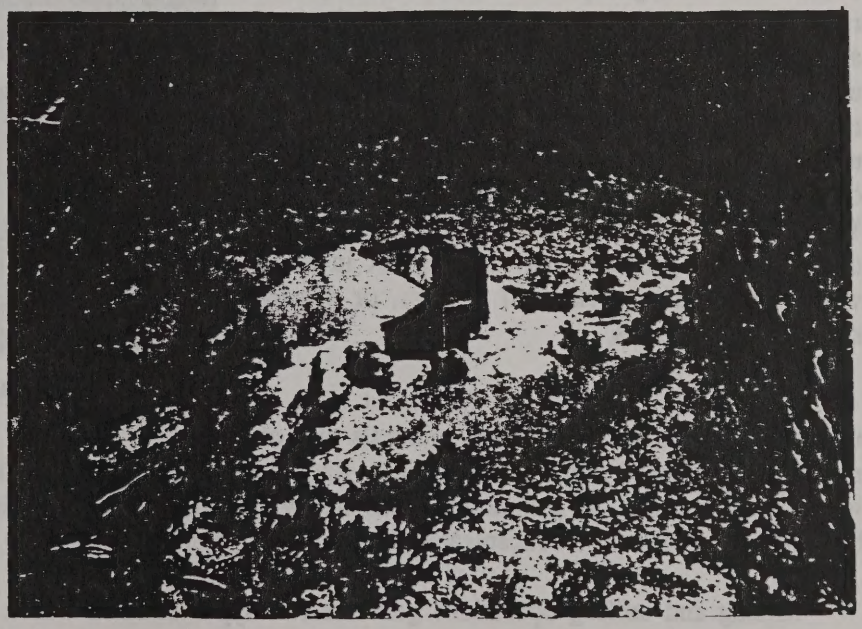


**Figure 3.–Abandoned mine site.**

## POTENTIAL HAZARDS AT MINERAL SITES

A hazard is considered to exist if: (1) site conditions contribute to degradation of the environment or human health on or adjacent to the site, or (2) physical site conditions could lead to human injury or death. Appendix I provides a listing of AML site features and associated hazards.

Environmental hazards include, but are not limited to, the presence of toxic, corrosive, radioactive, or otherwise noxious metals, chemicals, or materials, or unusual environmental conditions resulting from mining and/or milling operations (fig. 4). The hazards, depending on severity, may or may not represent violations of environmental law. Physical hazards include, but are not limited to, unsafe structures, dangerous mechanical equipment, underground mine workings, concealed shafts or pits, and explosives.

### Environmental Hazards Related to Minerals

Although minerals-related chemical hazards include many metals, certain metals currently are considered of critical significance according to EPA ecological risk assessment guidelines; these include lead (Pb), zinc (Zn), arsenic (As), and mercury (Hg). Lead and zinc commonly are referred to as "base metals," arsenic may be associated with gold deposits, and mercury may occur with either group. All occur naturally as a result of mineral deposition processes. Lead, zinc, and mercury also are of economic interest; arsenic usually is an unusable byproduct. These metals may be introduced into the environment through the natural process of erosion of mineral deposits or through mining and milling of these deposits. When introduced by the latter, metals or mineral decomposition products may be present in mine water, mine dump rock, mill tailings, or nearby soils or water bodies.

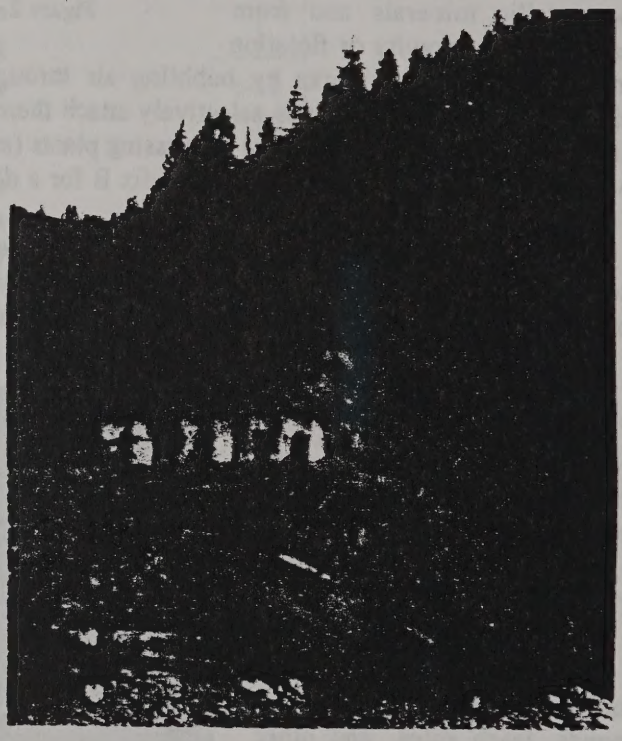


**Figure 4.–Abandoned mill site.**

Radioactive minerals can be found both at mines that produced radioactive minerals and at mines that produced other commodities. Radioactive minerals are quite soluble in water. Phosphate, while not hazardous, is commonly associated with radioactive minerals and heavy metals which may become liberated and/or concentrated during mining and processing.

Mining and milling operations generate two types of solid waste: mine waste and tailings (for a regulatory definition of mine wastes as hazardous substances, the reader is referred to 40 CFR 261). Mine waste is that material, which was removed from the ground during the excavation of underground workings, that cannot be processed economically, or overburden removed from placer deposits or open pit mines. Waste rock typically ranges from sand-size particles to boulders several meters in diameter.

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See figure 5 for an example of a waste dump.

Mill tailings, on the other hand, have a much different texture than waste rock (fig. 6). Tailings are the result of the milling process where ore is crushed to sand-size or smaller particles. Water and extraction chemicals may be added after grinding, and the resulting slurry is processed (flotation) to remove the ore minerals. The residual slurry is disposed of after the valuable minerals have been removed.

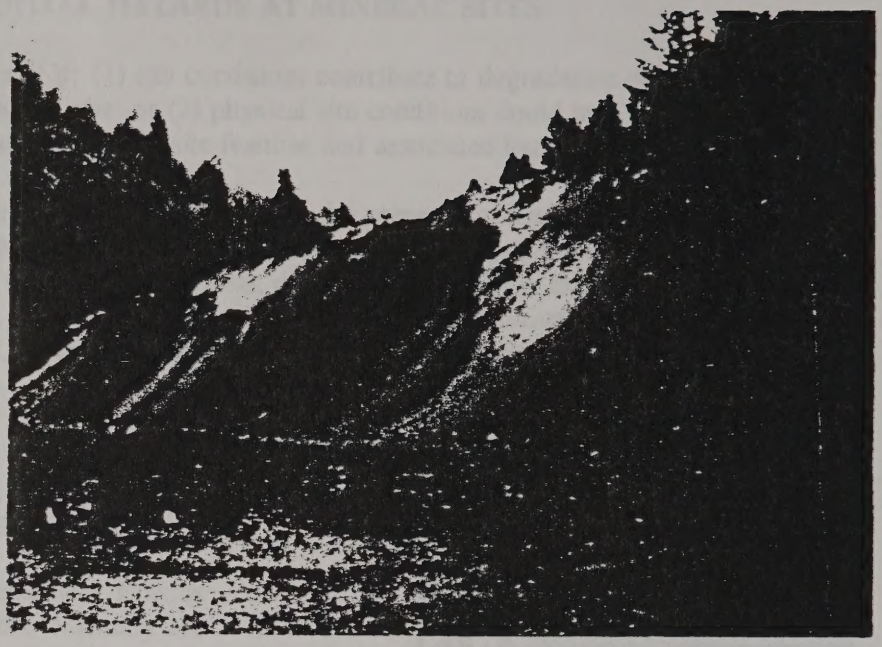


**Figure 5.–Mine waste dump.**

Past disposal methods have included deposition on the ground downhill from the mill or piping to an adjacent stream or settling pond.

The term "tailings" also is used in reference to placer mining waste. As the valuable commodity (usually gold) is separated from gravel in the wash plant, waste material is discarded at the downstream discharge of the plant. In the case of non-dredge plants, the waste is stacked in a convenient location by earthmoving equipment, whereas in the case of floating dredge operations, tailings are ejected from the rear of the plant with a waste-stacking apparatus.

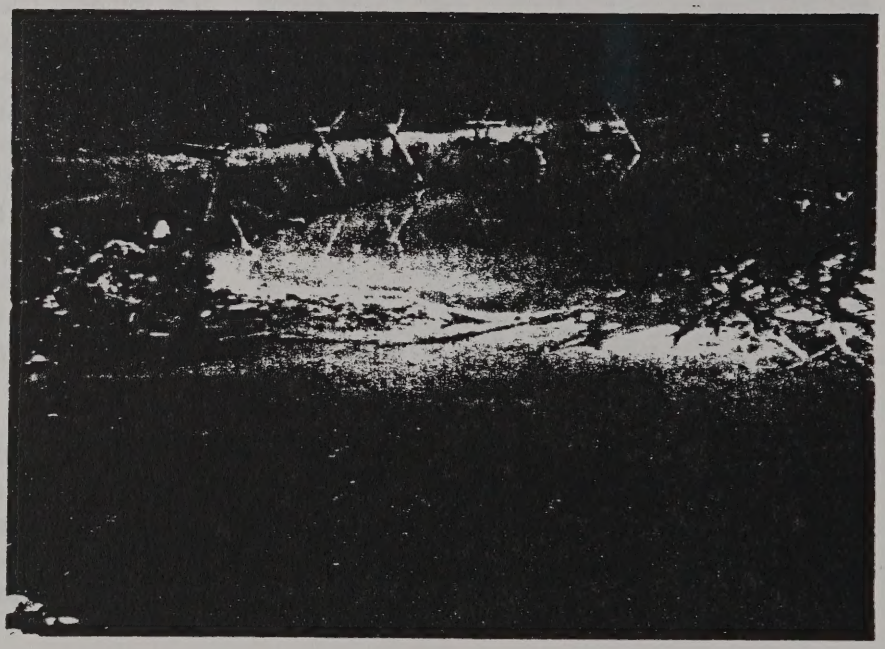


**Figure 6.–Mill tailings pond.**

Many mine and mill waste materials contain sulfides (metallic ions in combination with sulfur) which can, when exposed to air and moisture, generate sulfuric acid ($H_2SO_4$). The reaction between pyrite (iron sulfide), oxygen, and water is the primary acid producer, and the rate of this reaction can be accelerated significantly by the presence of a bacteria,

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*Thiobacillus ferroxidans*. The acid produced can dissolve base metal sulfides and release the metals to solution. The dissolved metals then can be transported by surface or ground water to the surrounding environment (fig. 7). Acidic, metal-bearing waters can be harmful to aquatic biota and other users. The often-associated deposition of iron oxide and iron oxyhydroxide sludges can fill or restrict flow in streams and cover the stream substrate used by aquatic animals and plants. Not all mine and mill wastes will generate acid water because the host rock containing the sulfides may be of a composition (primarily carbonates) that neutralizes any acids formed or pyrite may not be present in significant concentrations.



**Figure 7.–Iron oxide stain on rocks in stream.**

## Environmental Hazards Related to Processing Chemicals

Mineral processing uses a variety of chemicals (reagents) for mineral recovery. Many of these chemicals have changed over time; those used years ago often have been replaced by new ones. In addition, the number of new reagents expands constantly. Because of this, the number of individual minerals-related processing reagents is too large to list individually. However, they may be listed by groups. Table 1 lists groups of reagents, the decade in which they were commonly used, and the mineral commodity groups for which they were used. If one knows enough about the history of an AML site, table 1 allows one to predict the reagents that might be expected at that site. If any of these reagents are still present on site, they may be found in old mill buildings, storage sheds, work shop areas, garbage dumps, or containers within waste piles.

Almost all reagents are EPA critical (a class of hazardous waste) in one sense or another. However, most processing reagents decompose over time when exposed to the natural elements. Hence they are unlikely to be found free in tailings except at recent milling operations or under unique conditions that cause them to somehow be encapsulated. Mercury is a notable exception as it is quite persistent.

Cyanide, also a mineral processing reagent, has a long history of use and is often of public concern. A detailed discussion of all the pertinent controlling factors and considerations is beyond the scope of this handbook; but, in general, pure cyanide will decompose in nature under oxidizing conditions. Under anaerobic (oxygen deficient) conditions, such as might be found in the interior of a tailings pile, cyanide may remain. Cyanide can be transported by water when pH is 7 or greater (alkaline). Cyanide can also form cyanide-metal complexes that are hazardous.

**Table 1.–Historical use of "EPA Critical" mining chemicals for evaluation of environmental hazards of abandoned mine tailings**

| Period | Commodity | | | | | |
|---|---|---|---|---|---|---|
| | Iron | Sulfides | Gold | Uranium | Phosphate | Other industrial minerals |
| 1920-1929 . . . . | alum | alum | Hg | - | alum | alum |
| 1930-1939 . . . . | alum | xanthate<br>pine oil<br>alum | Hg | - | alum | alum |
| 1940-1949 . . . . | alum<br>pine oil<br>NaCN<br>alum | xanthate | Hg | - | alum | alum |
| 1950-1959 . . . . | alum<br>fatty acid<br>fatty amines<br>NaCN<br>alum | xanthate<br>thiocarbinilides<br>pine oil<br>pine oil<br>alum | Hg<br>NaCN<br>xanthate | HCl<br>$H_2SO_4$<br>$NaHCO_3$ | alum<br>fatty acid | alum |
| 1960-1969 . . . . | alum<br>fatty acid<br>fatty amines<br>polyacrylamides<br>pine oil<br>NaCN<br>alum<br>polyacrylamides | xanthate<br>thiocarbinilides<br>thiocarbanates<br>sulfhydrl anionics<br>alum<br>polyacrylamides | Hg<br>NaCN<br>xanthate<br>pine oil | HCl<br>$H_2SO_4$<br>$NaHCO_3$<br>polyacrylamides | alum<br>fatty acid<br>polyacrylamides | alum<br>polyacrylamides |
| 1970-1979 . . . . | sulfhydryl anionics<br>fatty acid<br>fatty amines<br>polyacrylamides<br>alcohol frothers<br>water glass dispersants<br>alum<br>polyacrylamides<br>petroleum sulfonates<br>alcohol frothers<br>water glass dispersants | xanthate<br>thiocarbinilides<br>thiocarbanates<br>sulfthydryl anionics<br>pine oil<br>NaCN<br>sulfhydryl anionics<br>water glass dispersants | thiocarbinilides<br>NaCN<br>xanthate<br>pine oil<br>alcohol frothers<br>polyacrylamides | HCl<br>$H_2SO_4$<br>$NaHCO_3$<br>polyacrylamides | fatty amines<br>fatty acids<br>polyacrylamides<br>alcolhol frothers | fatty amines<br>fatty acids<br>polyacrylamides |
| 1980- . . . . . | sulfthydryl anionics<br>fatty acid<br>fatty amines<br>polyacrylamides<br>alcohol frothers<br>water glass dispersants | xanthate<br>thiocarbinilides<br>thiocarbanates<br>sulfthydryl anionics<br>pine oil<br>NaCN<br>alum<br>polyacrylamides<br>petroleum sulfonates<br>alcohol frothers | thiocarbinilides<br>NaCN<br>xanthate<br>pine oil<br>alcohol frothers<br>polyacrylamides<br>water glass dispersants | HCl<br>$H_2SO_4$<br>$NaHCO_3$<br>polyacrylamides | fatty amines<br>fatty acids<br>polyacrylamides<br>alcolhol frothers | fatty amines<br>fatty acids<br>polyacrylamides |

## Other Chemical and Associated Hazards

Polychlorinated biphenyls (PCB's) are a carcinogenic class of manufactured chemicals. PCB's were first marketed in 1929 and have had a variety of applications in the electrical industry. Their most widespread use was as an additive to oils used to cool large electrical transformers (fig. 8) and capacitors (1).[1]



Figure 8.—Oil-cooled transformer.

Gasoline and diesel fuel, in addition to other petroleum products such as lubricating oil, hydraulic fluid, brake fluid, and grease are essential to the operation of mine and mill equipment. Petroleum products may have been stored in cans, buckets, barrels, or above- or below-ground storage tanks. Maintenance shops and storage buildings are likely places to find petroleum products.

Asbestos derived from some asbestiform minerals can be hazardous to humans because of its fibrous nature and tendency to break into microscopic particles. Airborne fibers may accumulate in the lungs and irritate lung tissue. In recent years regulations have been enacted controlling the use of asbestos; but, prior to regulation, asbestos commonly was used for insulation around hot equipment, pipes, ducts, and as an additive to construction materials as a fire retardant.

Stream sedimentation can occur in and near AML sites as a result of the erosion of mine waste and tailings, or the erosion of any portion of the site where the natural hydrologic regime or vegetative cover has been disturbed. Sedimentation poses a threat to indigenous flora and fauna as well as water quality.

Blowing dust contributes to erosion of the site and may cause mobilization of contaminants contained in tailings piles and waste dumps, and the subsequent deposition of those contaminants in areas distal to the site.

## Physical Hazards

Numerous types of physical hazards can be found within an AML site. Types include unexpended explosives, dilapidated buildings and other surface structures, mechanical equipment, scrap materials, open workings, unstable ground, tram cables, and animals.

### Explosives and Blasting-Related Items

Materials used for blasting can be classified into three general groups: explosives, initiators, and accessories. Explosives are manufactured to be relatively insensitive and must have initiators to start the chemical reaction of the blast. Initiators, on the other hand, are very sensitive, even when fresh from the factory. Accessories include the electrical generators, gauges, and miscellaneous items needed for blasting.

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[1]Underlined numbers in parentheses refer to items in the list of references cited.

The most widely used explosives in mining have been black powder, dynamite, and ammonium nitrate with fuel oil (ANFO). Black powder was extensively used in the 1880s but gradually was replaced by dynamite after the turn of the century (2). Black powder may be found in cans, kegs, or bags.

Dynamite is manufactured in the familiar stick form, which is approximately 20.3 cm (8 in) long and 2.5 cm (1 in) in diameter, and may be packed in wooden or cardboard boxes (fig. 9). Dynamite is composed of nitroglycerine and an inert filler, such as sawdust or clay, with the mixture wrapped in a paper roll. Nitroglycerine alone is very unstable, but when mixed with the filler it is relatively stable. Unfortunately, over a period of years, nitroglycerine can seep out of the filler (fig. 10) into the packing box or on to the underlying shelf, floor, or ground. **THE NITROGLYCERINE CAN EXPLODE IF DISTURBED: THIS IS AN EXTREMELY DANGEROUS SITUATION.**



**Figure 9.–Old dynamite in cardboard container.**

ANFO has gained popularity in mining since it was introduced in the mid-1930's. The two ingredients, ammonium nitrate and fuel oil, are relatively inert by themselves. Only when thoroughly mixed together in the correct proportions will they form a mixture that can cause a blast, and even then a strong explosive such as dynamite must be used to initiate the blast (2). ANFO may be found in metal or cardboard containers or paper bags.

Initiators used with explosives include blasting caps and detonation cord. Blasting caps are manufactured as 2.5 cm (1 in) long metal tubes that are about the diameter of a pencil. Two types of blasting caps have been produced: electrical and nonelectrical. **BOTH CAN EXPLODE IF MISHANDLED AND THUS ARE EXTREMELY DANGEROUS.**



**Figure 10.–Dynamite showing seepage and nitroglycerine "beads."**

Electrical blasting caps have two thin, color-coded wires emerging from one end. During blasting operations, caps are connected with detonation wire to an electricity-generating blasting machine (fig. 11). Nonelectrical blasting caps are designed to be used with a time fuse--a fabric or plastic covered cord with black powder in the center. The blasting cap is attached to one end of the fuse and the opposite end is lit with a flame. Time fuse is relatively stable.

Like a time fuse, detonation cord also has a fabric or plastic outer layer and an inner core of explosive. Detonation cord must be initiated by a blasting cap and, when detonated, explodes along its entire length. Detonation cord is relatively stable.

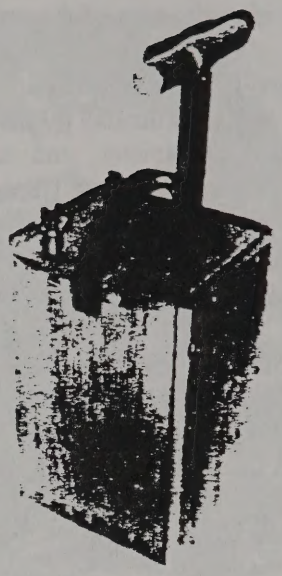


Figure 11.–30-cap blasting machine.

Buildings and Other Structures

The structural integrity of a mine or mill building is dependent upon the preparation of the foundation, the type of construction materials used, the age of the structure, and the climate. Although the availability of funds and materials were controlling factors, many buildings were intended to be temporary shelters and were constructed accordingly.

Abandoned buildings also can pose threats in ways unrelated to mining. Buildings offer excellent habitat to a variety of potentially dangerous animals such as snakes, scorpions, spiders, bees, wasps, hornets, and rodents. In recent years illegal drug manufacturers have discovered and taken advantage of the remoteness and existence of AML site buildings. The hazards of entering such buildings extend beyond the presence of reagents. Operations are frequently protected by armed guards and/or booby traps. If an illegal drug operation is discovered or suspected, vacate the site immediately and contact the proper authorities.

## Mechanical Equipment

Two types of equipment can be found at an AML site, heavy and light, and it is the former that can be hazardous. Heavy equipment can include crushers, grinders, engines, boilers, flotation cells, screens, vats, trams, ore cars, conveyors, and bins (fig. 12). All can cause injury, especially if not well secured.

Wires and cables may be associated with equipment. They are dangerous if they can be contacted by aircraft.

## Underground Hazards

Entryways into abandoned underground workings (portals, shafts, caved open stopes, caved raises, and ventilation raises) can be extremely dangerous due to failure of support timbers by decay or collapse (fig. 13). Unsupported rock in and around these openings can suddenly collapse if disturbed. In addition to the possibility of rock failure in underground workings, unstable explosives, vertical mine passages, or oxygen-deficient, toxic, or explosive gases that may exist in the workings can result in severe injury or death. UNDER NO CIRCUMSTANCES SHOULD UNTRAINED PERSONNEL ENTER UNDERGROUND WORKINGS.

### Scrap Materials

AML sites often contain large quantities of scrap lumber, metal, and materials. Cuts and punctures can result, along with injuries due to tripping.

### Pits, Ditches, and Highwalls

Small pits and trenches are not particularly hazardous unless they are concealed. The same is true for ditches except that ditches may have been used to route mine water, tailings, acid drainage, or other potentially contaminated fluid. Highwalls are the steep slopes left by mining in large open pits, quarries, and sand and gravel pits. The risk posed by a highwall depends on its height, slope, and stability.



Figure 12.–Example of heavy equipment.

### Subsidence

Ground subsidence can occur when underground openings collapse. When an underground opening is the result of mining activity, the collapse can be the result of either the mining operation (block caving, sublevel caving, longwall mining, solution mining, etc.) or simple ground failure. Failure can be rapid or slow and triggered by surface activity. Underground failure may be expressed at the surface as a depression. Once subsidence has occurred, additional subsidence is likely.

### Impoundments

Impoundments often are used as a water supply for a mining or milling operation or as settling ponds for tailings slurries. Under certain circumstances, such as heavy rainfall or rotten timbers, the dam may fail and release water, sediment, or contaminants within the impoundment to the surroundings.



Figure 13.–Example of hazardous portal.

## AML INVENTORY

### Purpose

AML inventories are conducted to determine the location of inactive and abandoned mines and to document the presence or absence of the hazards described previously. An inventory is the first phase of a multiphase process and includes four steps; two data steps and two filter steps. Each step is described in detail in upcoming sections.

## AML PROCESS

### Inventory Phase

| Step I -> [Data] | Step II -> [Filter] | Step III -> [Data] | Step IV [Filter] | | Filter | |
|---|---|---|---|---|---|---|
| Develop initial site list. | Select field study sites. | Conduct field studies. | Identify future action sites. | -> | Site Characterization Phase | - > Remediation Phase |

Filters are important because they allow investigators to categorize AML sites as to their priority for future actions. They also are a tool for planning the allocation of personnel and financial resources. The resource cost per site escalates rapidly from one step or phase to the next. Filters allow planners to selectively reduce the number of sites to be considered in each ensuing step or phase. How conservatively or liberally the filtering is done is a function of the risk tolerance of the concerned agency or office. As a rough guide, based on the results of the few AML inventories conducted to date, 2 pct of the total number of sites will warrant site characterization and 10 pct of those will require significant remediation.

With respect to the CERCLA process, the inventory phase is analogous to the combined Preliminary Assessment (PA) and Site Investigation (SI), and the site characterization phase is analogous to the Remedial Investigation and Feasibility Study (RI/FS). Remediation is the same for both processes.

The proactive application of the AML process should prevent all but the worst sites from being investigated under the CERCLA process. For an average site (a broad range exists), the costs for the three phases, inventory, site characterization, and remediation, are shown below. Under the CERCLA process, costs for these phases would be tens of thousands, hundreds of thousands, and millions of dollars, respectively.

| | Personnel | Financial |
|---|---|---|
| **Inventory:** | | |
| Pre-field: | 10 sites/day | Salary - 1 technician |
| Field: | 1 site/day | Salary - 1 technician |
| **Site Characterization:** | | |
| Field: | 1 site/3 weeks | Salary - 3 specialists<br>Samples - $10 to $100 each |
| Post-field: | 1 site/26 weeks | Salary - 2 specialists |
| **Remediation:** | | |
| Pre-field: | 1 site/10 weeks | Salary - 3 specialists |
| Field: | 1 site/2 weeks | Salary - 3 specialists<br>Heavy equipment rental<br>Salary - equipment operator<br>Supplies |

## Approach

Development of an AML inventory requires: (1) identification of all mineral sites in the area under investigation; (2) compilation of baseline data, including location, history, status, and type of operation for each site; (3) a site examination (1/2 day on site) to identify and record actual and potential hazards; and (4) priority listing of sites for future actions, including site characterization and remediation.

A critical aspect of the inventory process is collecting comparable site-specific data in a consistent manner. This is best accomplished using a standardized form. An AML inventory form is provided in this handbook (appendix C). This form is designed to work with all types of AML sites and contains both pre-field and field data. The next four sections of this handbook are devoted to explaining what pre-field data to collect and record on the form and how to obtain it, a procedure to filter the pre-field data, what field data to collect and record on the form, and a means to evaluate the field data.

## STEP I–DEVELOP A LISTING OF AML SITES

The first step in the AML inventory/evaluation process consists of amassing pre-field site data, recording the data on Part I (the pre-field section) of the AML Inventory form referred to in the previous section, creating a computer file to store the data, and developing a listing of AML sites. There are a number of sources of information available to accomplish this step, some better than others, some more available than others.

### Sources of Information

A vast body of mine and minerals-related information has been collected and recorded. The major portion of this information resides in Federal, State, and local governmental institutions and agencies. Information sources are numerous and widespread and could present an AML investigator, often working under stringent time and funding constraints, with a challenge to acquire as much quality information as possible within these constraints. The following sections discuss the major sources of information available to the AML investigator; other less known sources are briefly mentioned.

### U.S. Bureau of Mines (USBM)

Since its creation in 1910, the USBM has documented, tracked, investigated, and reported on thousands of domestic mines and minerals-related activities. The USBM is a major minerals research and information agency which has principal Federal responsibility for collecting, interpreting, and analyzing information involving mineral resources and the production, consumption, and recycling of mineral materials. For these reasons, the Bureau probably is the best single source of information with regard to abandoned mine land identification and evaluation.

The following sections describe some of the most important and useful (from an AML perspective) sources of information within the USBM. Because of the volume of information available, the AML investigator probably will not need to, or have sufficient time to, refer to all of the references discussed below. The selection of information sources will be based on project time constraints and the availability of the references.

#### Mineral Industry Location System (MILS)

Mine and minerals-related information derived from Federal, State, local, and private sources, has been compiled and entered into the Bureaus' Minerals Availability System (MAS) computer database. Of prime interest to an AML investigator is the Mineral Industry Location System (MILS), the locational subset of the larger MAS database. MILS locates and provides information on mineral industry sites throughout the world. These mineral industry sites or "mineral industry locations" include metallic and nonmetallic occurrences, prospects, mines (both past and present producers), geothermal wells, and mineral processing plants such as mills, smelters, and refineries. Currently, more than 200,000 domestic mineral industry locations are resident in MILS. Mineral locations for the State of Nevada are shown in figure 14, a density plot wherein each MILS location is represented by a single dot.

MILS data are typically obtained as paper printouts; however, in some cases the data may be available on genetic tape or diskettes. Refer to appendix F for information on how to obtain MILS and other USBM data.

Since the majority of MILS entries are reported from the body of minerals-related literature, MILS data coverage may range from basic locational, commodity, and bibliographic information to complete property descriptions. The following basic data always are present on a MILS printout:

- Deposit name.
- The State in which the property is located.
- The county in which the property is located.
- The 10-digit sequence number.
- A valid latitude and longitude.
- At least one mineral commodity.

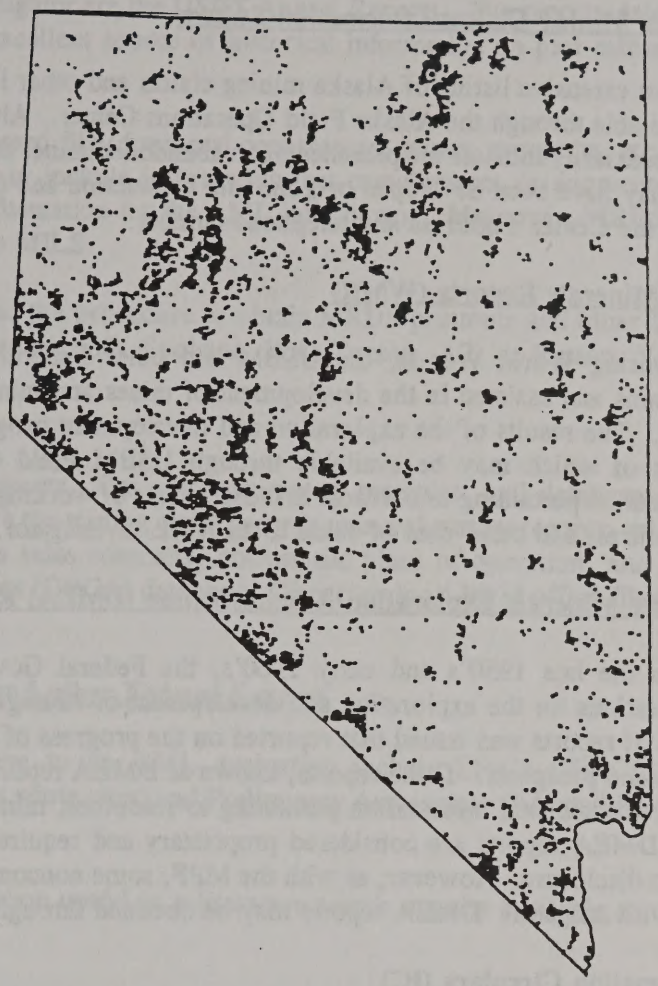


**Figure 14.–Density plot of MILS locations in the State of Nevada.**

## Mineral Property Files

The USBM maintains extensive mineral property files (MPF) for both producing and past producing mining operations. In most part, the files contain proprietary information such as ore reserves and capital and operating cost data that cannot be disclosed except with the owner's written permission. However, the files may contain information of a nonconfidential nature that would be of value to an AML investigator. Specific information such as extent of workings, milling methods (an indicator of what chemicals may have been used), ore and waste minerals, years of operation, among others, may be available.

## Mineral Land Assessment (MLA) Reports

The Wilderness Act of 1964, the Federal Land Policy and Management Act of 1976, and other related acts require the USBM and the U.S. Geological Survey (USGS) to conduct mineral assessments of public lands considered for inclusion in the National Wilderness Preservation System. The USBM conducts field surveys to support multiple-use management of Federal lands with mineral resource information. Descriptions of these studies are published in the form of USBM Special Publications and open-file reports and often are summarized in joint USBM/USGS reports published by the USGS. The reports represent a valuable source of information for the AML investigator.

### Alaska Mining Claims Information System

An extensive listing of Alaska mining claims and other information helpful to the AML investigator is available through the Alaska Field Operations Center. Although the presence of a mining claim does not necessarily indicate the presence of an abandoned mine, the system references claims filed in the past that may have been developed or gone into production and may now be abandoned. Refer to appendix F for the Center's address and telephone number.

### War Minerals Reports (WMR)

During World War II, the USBM and other Federal agencies engaged in mineral exploration programs and assisted in the development of mines and mineral processing facilities as part of the war effort. The results of the exploration and development programs were compiled in a series of reports, copies of which may be available through USBM Field Operations Centers. WMRs may contain information pertaining to borehole drilling, extent of workings, geology, mineralogy, mineral processing procedures, and other data of value to an AML investigator.

### Defense Minerals Exploration Administration (DMEA) Reports

In the late 1950's and early 1960's, the Federal Government granted loans to individuals and corporations for the exploration and development of strategic mineral resources. As with the WMR, a series of reports was issued that reported on the progress of the exploration and development at various mines and prospects. These reports, known as DMEA reports, although generally fiscal in nature, often included incidental information pertaining to resources, minerals, extent of workings, borehole results, etc. DMEA reports are considered proprietary and require written permission of the property owner before disclosure. However, as with the MPF, some nonconfidential information may be available to an AML investigator. DMEA reports may be obtained through selected USBM or USGS offices.

### Information Circulars (IC)

The USBM IC series is an excellent source of information including surveys of mineral resources and related mining and milling activities, compilations of historical and statistical data on minerals, and bibliographies. Detailed reports of minerals-related activities for an entire State, for a county or counties within a State, or local mining districts also are found in this series.

Additional USBM sources of information include Reports of Investigation (RI), Bulletins, mineral commodity reports, Minerals Yearbooks, Open-File reports (OFR), and special publications.

## Other Federal Government Sources of Information

### U.S. Geological Survey

The USGS collects, compiles, analyzes, and publishes a great volume of geological information in its Bulletins; Professional Papers; Water Supply Papers; Circulars; Memoirs; topographic, geologic, and hydrographic maps; reports; unpublished file data; OFRs; and miscellaneous publications. In addition, personal journals, notes, unpublished reports, and other sources of information may be available at local USGS offices.

Of particular interest to the AML investigator are the USGS Annual Reports. The reports date from before the turn of the century and are an excellent source of historical information on past mining and milling operations.

The USGS also maintains a computer-based file of mineral occurrences, mines, prospects, etc. The Mineral Resource Data System (MRDS) may include information that complements or augments data resident in MILS and is a good source of information for the AML investigator. Moreover, MRDS may list mines and prospects not yet entered into MILS.

For information pertaining to MRDS and the procedure to obtain MRDS printouts and other USGS information, contact the USGS offices in Denver, CO, Spokane, WA, Tucson, AZ, or Reston, VA.

**Bureau of Land Management (BLM)**

BLM sources of information include reports, files, records, notes, memoirs, and databases. Of particular interest to the AML investigator are the mining claim records, mineral survey records, mineral reports, lease information, mineral materials sales contracts, notices and plans of operation, and Case Recordation/On-Line Recordation Case Access (ORCA) database. District or local BLM office files may also provide useful AML information.

**Environmental Protection Agency (EPA) and other Federal Sources**

Possible sources of information germane to an AML evaluation include EPA's CERCLIS (a computerized inventory of potential hazardous waste sites) and Preliminary Assessment (PA) and Focused Site Inspection (SI) files.

Other mines and mineral-related information useful in a literature search may be available through the following Departments or agencies:

- Department of Energy (DOE) reports;
- Office of Surface Mining (OSM);
- Mine Safety and Health Administration (MSHA);
- National Archives (NA);
- Library of Congress (LC);
- U.S. Department of Agriculture Forest Service
- U.S. Departments of Commerce (DOC), Labor (DOL), and Defense (DOD);
- Internal Revenue Service (IRS).

**State and Local Governments**

Mining-related information often is available at State mining bureaus or departments of geology, historical societies, offices of the State mining inspector, State AML offices, State Departments of Ecology, Public Health and Safety offices, agencies with permitting or licensing responsibilities, highway departments, utilities commissions, libraries, and museums.

Local government sources include records of the county or city clerk, county and city tax assessors, highway and road departments, public utilities, libraries, and agencies with permitting or licensing responsibilities.

### Private Sector

Business and nonprofit organization sources of information include mining and/or mineral exploration companies, historical societies and museums, industry and/or trade associations, mining consultants, etc. Commercial databases such as DIALOG and GEOREF[2] provide important information and references.

### Educational Institutions

Sources of information may include, but are not limited to, college and university departments of geology, mining, geophysics, geochemistry, hydrology, history, economics, social science, and their respective libraries.

University Microfilms International, 300 N. Zeeb Road, Ann Arbor, MI 48106, maintains a clearinghouse for doctoral dissertations that may contain locational, rock, mineral, historical, and other information of interest to an AML investigator.

### Aerial and Satellite Photography and Imagery

Certain information pertaining to AML sites can be determined from aerial and satellite photography and imagery. Aerial photography can provide location, size, approximate area of land disturbance; surface area of dumps and tailings; and the presence, location, and approximate size of buildings, access roads, and related features. For satellite imagery, site information is limited to larger sites or features. These areas can be identified and marked on maps prior to fieldwork. Imagery is especially useful in semiarid and arid regions with sparse vegetation.

A variety of image or photographic data types or platforms are available. These include low, medium, and high altitude aerial photos (color, black-and-white, false color infrared); videography (video cameras attached to aircraft); U-2 high altitude infrared photography; airborne imaging spectrometers; and satellite imagery. Aerial photos and U-2 photos are available in image positives or negative transparencies. Satellite imagery is available in these formats and as digital data. Aerial photography has the advantage of high resolution, but generally covers relatively small areas. Conversely, satellite imagery has lower resolution, but covers larger areas.

Aerial photography is available from a variety of domestic sources, including the Department of Agriculture.[3] Scale, and associated resolution varies with altitude; lower altitude gives higher resolution.

Satellite imagery is available from both domestic[4] and foreign sources[5] in digital or hardcopy form, color or black-and-white format, and of varying age and resolution. Earlier American MSS (Multi-

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[2]Use of trade or corporate names herein does not constitute endorsement by the U.S. Bureau of Mines.

[3]U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service, Aerial Photography Field Office, 2222 West, 2300 South, P.O. Box 30010, Salt Lake City, UT 84130-0010.

[4]U.S. Department of Interior, U.S. Geological Survey, Eros Data Center, User's Service Section, Sioux Falls, SD 57198; information telephone no.: (605) 594-6151; facsimile telephone no.: (901) 668-0310. (MSS Imagery from LandSat 1, 2, 3, and 4).

EOSAT Corp., Customer Services, 4300 Forbes Blvd., Lanham, MD 20706; information telephone no.: (800) 344-9933; facsimile telephone no. (301) 552-0537. (TM Imagery from LandSat 4, 5, and 6).

[5]SPOT Image Corp., 1897 Preston White Drive, Reston, VA 22091-4368; information telephone no.: (703) 620-2200; facsimile telephone no.: (703) 648-1813.

Spectral Scanner) imagery has an 80 m resolution, has four data bands, is available in color, and is of limited use for evaluation of objects smaller than 80 m in diameter. More recent American TM (Thematic Mapper) satellite imagery has a 30 m resolution, is available in color, has seven data bands and is of greater use in AML work. The principal current foreign source of satellite imagery is from the French SPOT[5] (Systeme Probatoire d'Observation de la Terre) satellite which has 20 m resolution and is panchromatic (black-and-white).

## Using the AML Inventory Form–Recording Basic AML Site Information

Step I is best accomplished through a series of five intermediate steps, or tasks. Briefly, the tasks include:

Task 1. Area delineation and map acquisition.

Task 2. Acquire MILS data–record on AML Inventory Form, Part I-Pre-field data. The USBM MILS system is described in detail in Task 2.

Task 3. Map data. Develop site numbering system.

Task 4. If a large number of sites is anticipated, establish a computer file.

Task 5. Literature search.

The completion of Tasks 1-5 will result in a number of AML Inventory forms on which pre-field site data have been recorded, a computer file of AML sites, and a listing of AML sites for analysis in Step II. Each task of Step I is described in detail in the following sections.

## Task 1–Area Delineation and Map Acquisition

The first task of Step I consists of delineating the area of interest on topographic maps. A brief discussion of topographic maps, their use, and where they may be obtained is presented in appendix D. It is always good practice to use the largest scale maps available. However, if the area under investigation is extensive, for example a large portion of a national forest, it may first be necessary to mark off the boundaries of the study area on a smaller scale map such as one or more of the 1:250,000 (1° by 2°) map series. Then, using the appropriate index for the particular 1:250,000 map (available through most USGS map outlets), determine the names of the large-scale maps (30' x 60', 15 min, 7.5 x 15 min, or 7.5 min) within the study area. Once this determination is made, the appropriate maps should be acquired through the USGS Map Sales offices.

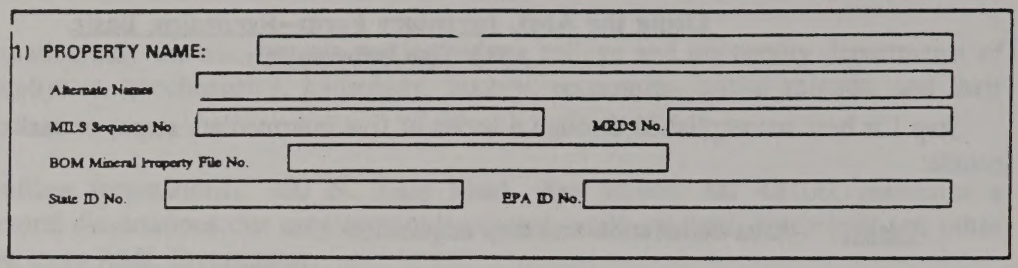
## Task 2–Acquire MILS Data–Record Data on AML Form

Task 2 entails the acquisition of MILS data and entering pertinent information on the AML pre-field form. This is particularly important in that it establishes the framework and provides important property references for the subsequent literature search which, in turn, provides additional data for the filter processes described in Step II (pre-field data filter) and Step IV (post-field data filter). Appendix F provides information on how and where to obtain MILS information.

The following discussion describes the data fields in MILS that are germane to an AML investigation. Underlined numbers in parentheses following particular data fields relate the data of a specific field to specific line items on the AML pre-field form (fig. 15).

**Deposit (property) name (1)**—The primary or most commonly used deposit name. The term "deposit" as used here refers to any MILS entry.

**Name (alternate) (1)**—Alternate or secondary names associated with this property.




**Sequence number (1)**—A unique 10-digit number used to link various data tables within MILS and to link a particular MILS entry to specific mineral property files (see section entitled "Sources of Information—U.S. Bureau of Mines—Mineral Property Files") and to mine map repository files (see "Mine Map Repository" below).

**Geological Survey (1)**—This field links the MILS property to an entry in the USGS' Mineral Resource Data System (MRDS). Refer to the discussion of MRDS in the section "Other Sources of Federal Information— U.S. Geological Survey."

**Mineral property file (1)**—If this field contains any number, the property has additional information in a file maintained by the responsible Field Center. Refer to the discussion of mineral property files in the section "U.S. Bureau of Mines Sources of Information—Mineral Property Files."

**Mine map repository**—Some MILS properties have associated maps of underground mine workings. Such maps would be of value to an AML investigator in evaluating the physical hazards on site. In some cases the maps are proprietary and may not be disclosed without written permission of the property owner. A mine map repository field entry of "A" indicates the map is maintained by the USBM Alaska Field Operations Center; a "W" refers to the Western Field Operations Center; and an "I" indicates the Intermountain Field Operations Center. Addresses and telephone numbers for the three Field Centers are listed in appendix F.

**MLA Study area**—A "Y" or "Yes" entry in this field indicates the site or general area was studied under the MLA program and an open-file or other report may exist.

**Predominant mining method**—Describes the method(s) used to extract ore at the mine site. May provide valuable information in the evaluation of potential environmental and/or physical hazards.

**Maintaining Field Center**—The USBM Field Center that has responsibility for the maintenance of the particular MILS property and the Field Center to be contacted for further information.

**Mining district**—This field contains the name of the mining district in which the property is located. This information may be of use to determine the commodity(ies) or minerals in the area when such data are otherwise unavailable.

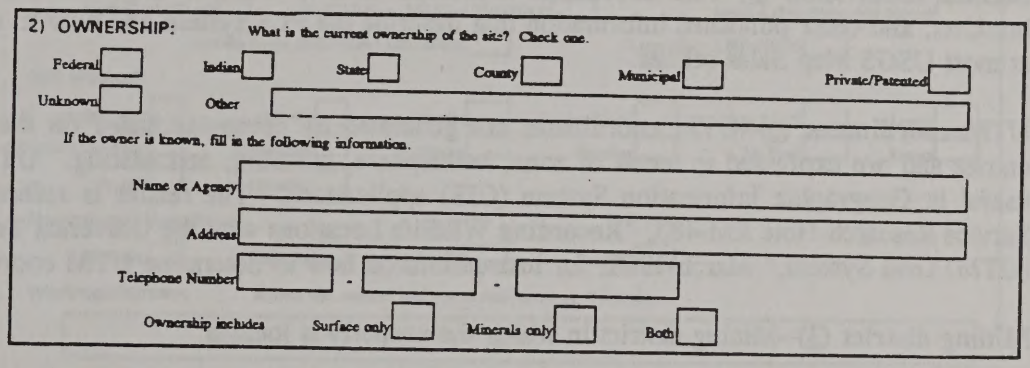
**Distance to water supply**–This datum, while of primary use to USBM engineers, may indicate the presence of surface waters proximal to the site, and may be of value in the evaluation of potential environmental hazards.

**Topography**–Entries range from "unknown" to "very rugged." This information may provide clues to possible physical hazards (in the cases of rugged–up to 450 m of local relief, and very rugged topography–greater than 450 m of local relief) and may help in logistical planning for site investigations.

**Name of owner** (2)–When property information other than that provided by MILS (or other nonproprietary sources of information) is unavailable, it may be necessary to contact the owner to get permission to acquire such proprietary data. By and large, ownership data in MILS is current as of the date of information (described below). If it is important to ascertain the current owner, the AML investigator is advised to make an inquiry of the county assessor's office in the county in which the property is located. Other sources of current ownership data may be State mining bureaus or State tax offices.

**Year of information**–The year in which the ownership information (see above) was current.

**Domain** (2)--Describes the type of public or private domain of the property.




**State** (3)–The State in which the property is located.

**County** (3)– The county in which the property is located.

**Map name and scale** (3)– The name and scale of the largest scale map on which the property is located, typically a 7.5- or 15-min map.

**Quadrangle** (3)–The quadrangle field identifies the USGS 1:250,000 (1° x 2°) series map on which the property is located.

**Latitude** (3)–Latitude coordinate expressed in degrees, minutes, and seconds north of the equator.

**Longitude** (3)–Longitude coordinate expressed in degrees, minutes, and seconds west of the Greenwich meridian.

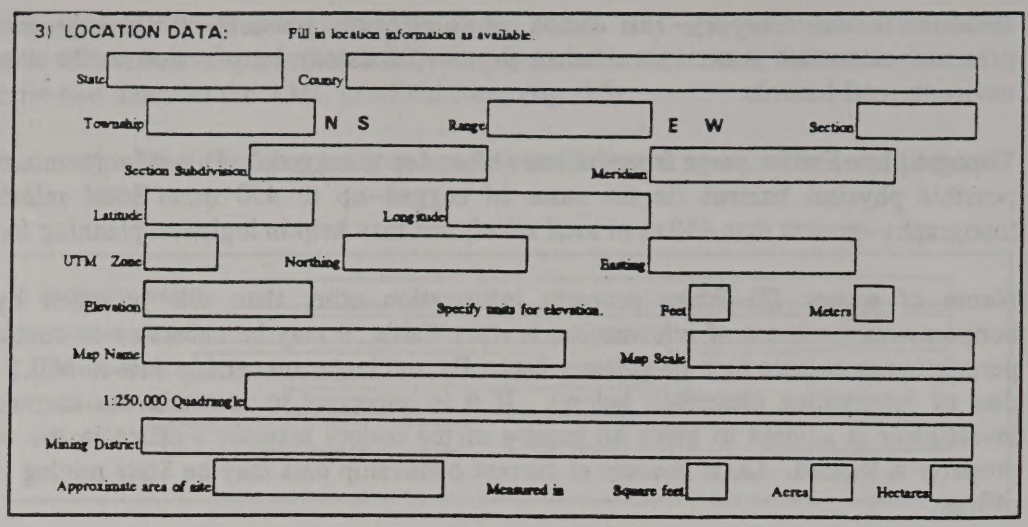
**Elevation** (3)– The elevation in meters of the point of reference. (See "Point of reference" below.)

**Principal meridian** (3)–The meridian on which the Public Land Survey (PLS) coordinates are based.

**Township** (3)–PLS coordinate expressed in 36-square mile increments north or south of the base line associated with the principal meridian.

**Range (3)**—PLS coordinate expressed in 36-square mile increments east or west of the principal meridian.

**Section (3)**—PLS coordinate of a 1-square mile portion of the 36-square mile area defined by township and range.




**Section subdivision (3)**—PLS coordinate expressed as 1/4, 1/16, or 1/64 of a section. Pamphlets, booklets, and other published information that describe the PLS system and how to use it are available at most USGS Map Sales offices.

**UTM coordinates (3)**—UTM coordinates are generated by computer based on the latitude/longitude entries and are expressed in terms of zone, hemisphere, northing, and easting. UTM coordinates are useful in Geographic Information System (GIS) applications. The reader is referred to U.S. Forest Service Research Note RM-483, "Recording Wildlife Locations with the Universal Transverse Mercator (UTM) Grid System," March 1988, for instructions on how to determine UTM coordinates on a map.

**Mining district (3)**—Mining district in which the property is located.

**Point of reference**—This is the physical determination point for the elevation and latitude and longitude. Point of reference may be the main entry of the mine, an exploration trench, the deposit ore body, a claim, pit, or plant (mill).

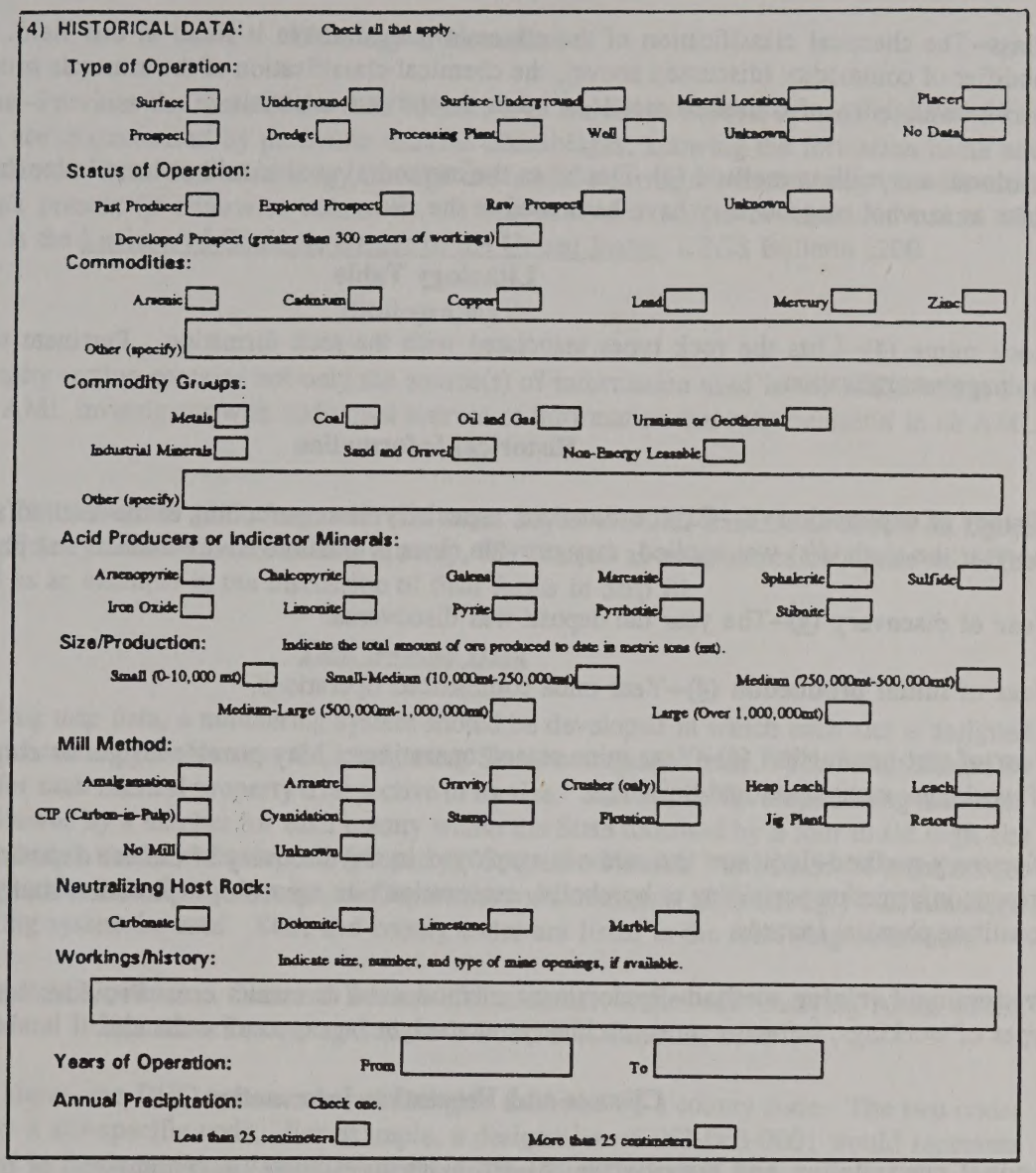
**Precision of point**—This gives the precision or maximum deviation from the exact point of reference in meters. Precision is expressed in increments of 10, 100, 250, 500, 1,000, 5,000, 10,000, and greater than 10,000 m. Thus, if a latitude/longitude location is given a point of reference of "Main entrance" and a precision of point of 250 m, then the AML investigator can assume that the mine main entrance would be within 250 m of the point described by the latitude/longitude coordinates.

**Elevation precision**—This gives the precision or standard deviation for the elevation measurement in meters. Elevation precision is expressed in increments of 10, 100, 500, and greater than 500 m.

**Type of operation (4)**—The type of mining/milling operation that existed on this site.

**Current status (4)**—Status of the property as of the date of the last property update. Status entries of the most importance to the AML investigator include "Past producer," "Developed deposit," "Explored prospect," "Raw prospect," and "Unknown." These entries indicate the level of mining activity that occurred at the property.

## Commodity Information


(4) HISTORICAL DATA: Check all that apply.

Type of Operation:

Surface ☐ Underground ☐ Surface-Underground ☐ Mineral Location ☐ Placer ☐

Prospect ☐ Dredge ☐ Processing Plant ☐ Well ☐ Unknown ☐ No Data ☐

Status of Operation:

Past Producer ☐ Explored Prospect ☐ Raw Prospect ☐ Unknown ☐

Developed Prospect (greater than 300 meters of workings) ☐

Commodities:

Arsenic ☐ Cadmium ☐ Copper ☐ Lead ☐ Mercury ☐ Zinc ☐

Other (specify)

Commodity Groups:

Metals ☐ Coal ☐ Oil and Gas ☐ Uranium or Geothermal ☐

Industrial Minerals ☐ Sand and Gravel ☐ Non-Energy Leasable ☐

Other (specify)

Acid Producers or Indicator Minerals:

Arsenopyrite ☐ Chalcopyrite ☐ Galena ☐ Marcasite ☐ Sphalerite ☐ Sulfide ☐

Iron Oxide ☐ Limonite ☐ Pyrite ☐ Pyrrhotite ☐ Stibnite ☐

Size/Production: Indicate the total amount of ore produced to date in metric tons (mt).

Small (0-10,000 mt) ☐ Small-Medium (10,000mt-250,000mt) ☐ Medium (250,000mt-500,000mt) ☐

Medium-Large (500,000mt-1,000,000mt) ☐ Large (Over 1,000,000mt) ☐

Mill Method:

Amalgamation ☐ Arrastre ☐ Gravity ☐ Crusher (only) ☐ Heap Leach ☐ Leach ☐

CIP (Carbon-in-Pulp) ☐ Cyanidation ☐ Stamp ☐ Flotation ☐ Jig Plant ☐ Retort ☐

No Mill ☐ Unknown ☐

Neutralizing Host Rock:

Carbonate ☐ Dolomite ☐ Limestone ☐ Marble ☐

Workings/history: Indicate size, number, and type of mine openings, if available.

Years of Operation: From To

Annual Precipitation: Check one.

Less than 25 centimeters ☐ More than 25 centimeters ☐

**Commodity (4)**--MILS lists more than 100 commodities that may be associated with a minerals-related operation. In many instances as many as 10 or more commodities were produced by a single operation. Commodities are generally referred to as "primary," the commodity of most importance; "coproduct," of equal importance to the primary commodity; "byproduct," recovered along with the primary commodity; "recoverable," commodity is present but not recovered in the operation; and other commodities that may be detrimental in milling or otherwise affect the marketability of the primary, coproduct, or byproduct.

**Modifier**--The modifier describes the chemical form in which the various commodities occur. This is very valuable information in that it may provide clues to the bio-availability of metals or other constituents that may pose a potential environmental problem.

### Minerals Table

**Name (4)**--The name(s) of the minerals present on-site are listed in this field. The listing includes ore minerals and minerals associated with the rocks surrounding the ore body ("country rock") and with waste rock ("gangue minerals"). These data are useful in evaluating the potential for environmental problems.

**Class**–The chemical classification of the minerals named above is listed in this field. Much like the modifier of commodity (discussed above), the chemical classification of the minerals provides insight to the bio-availability of contained metals or other deleterious materials.

**Predominant milling method (4)**–Describes the method(s) used to mill or beneficiate the ore. Provides clues as to what reagents may have been used at the site.

### Lithology Table

**Rock name (4)**–Lists the rock types associated with the rock formation. Pertinent to potential acid drainage/neutralization.

### Historical Information

**History of exploration (4)**–Exploration data, especially those pertaining to the method(s) employed and the year the method(s) was applied, may provide clues to possible environmental and physical hazards.

**Year of discovery (4)**–The year the deposit was discovered.

**Year of initial production (4)**–Year mine commenced operations.

**Year of last production (4)**–Year mine ceased operations. May provide insight or clues on conditions of workings, equipment, and buildings.

**Discovery method**–Indicates the methods employed in the discovery of the ore deposit. The data may provide information pertaining to boreholes, exploration pits, trenches, exploration shafts, etc., that may constitute physical hazards.

**Predominant mining method**–Predominant method used to extract ore. Provides insight as to what types of workings, infrastructure, machinery, etc. might be expected at the site.

### Climate and Vegetation Information

**Annual precipitation and distribution (4)**–Provides an estimate (in centimeters) of the area's annual precipitation (rain, snow, hail, etc.) and in what season of the year the most precipitation occurs. The data may be of value in evaluating the environmental hazard potential and in planning site examinations.

**Vegetation**–Provides information on the type(s) of vegetation found on and around the property.

**Climate**–Climate entries include "Unknown," "Subtropical," "Tropical," "Temperate," "Cool," and "Cold." Climate and precipitation have a bearing on potential environmental problems such as acid rock drainage.

### Ore Body Geometry Information

**Type of ore body, shape of ore body, and ore controls**–These fields are useful in Step II in that they assist in making a decision pertaining to the potential for both environmental and physical hazards and aids in the priority listing of site examinations.

### Lithology Information

**Formation name**—Provides the name of the rock formation in which the deposit or mine occurs. Since most formations are characterized by particular mineral assemblages, knowing the formation name and using it to ascertain the formation mineralogy through the use of a geologic lexicon, may provide clues as to the minerals present (if otherwise unknown). A recommended source of formation names and associated rocks is the Lexicon of Geologic Names of the United States, USGS Bulletin 1200.

### Bibliography

The bibliography section contains not only the source(s) of information used in the MILS entry, but may provide the AML investigator with additional sources of information that may be useful in an AML evaluation.

Figure 15 (p. 29) shows the AML form with line items keyed to MILS data fields shown on figure 16 (p. 31). The Grizzly Bear Mine, Shoshone County, ID, is used as an example on figure 16. The mine also is used as an example in the discussion of field forms in Step III.

## Task 3—Map Data

Before compiling map data, a numbering system should be developed in which each site is assigned a number. This process may be done at the local, area, State, or regional level. The result should be a unique number for each mineral property irrespective of its size. This can be developed using a number for each State, followed by a number for each county within the State followed by a four to six digit site number. This method is used for the deposit (property) "Sequence Number" in MILS. A standard set of State and county codes is available through the Department of Commerce. It is strongly recommended that the DOC coding system be used. State and county codes are listed in the following reference:

U.S. Department of Commerce, National Bureau of Standards. States and Outlying Areas of the United States. Federal Information Processing Standards Publ. 5-1, June 15, 1970.

As mentioned above, the DOC system uses a State code followed by a county code. The two codes can be followed by a site-specific code. For example, a designation of 053-063-0001 would represent AML site number 1 in Spokane County, WA. A code of 016-079-0025 would represent the 25th site in Shoshone County, ID. Enter the unique site number on each of the forms.

It is essential to plot the location of each site on the appropriate map. Plotting is best accomplished in two steps. First, obtain a small-scale map as described in Task 1 and plot all of the sites with site reference numbers. Then place a dot on the map for each site or group of sites. Identify these sites by using the "Site No." which was entered on line 1 of the AML forms. This map will be used to develop field plans described in Step III.

Next, perform a careful map-by-map examination, noting the names, locations, elevations (and other map data as required on the pre-field form that may be missing from the MILS printouts) of all mines, prospects, and any associated mills. Be advised that in most cases minor mines and prospects are not identified on the map(s) by name if, indeed, the property has a name. The locations of the mines or prospects can be determined directly from the map in terms of three locational systems: PLS system coordinates, latitude and longitude, or UTM coordinates. See Greenhood (3) for an in-depth discussion of maps and related materials. Map data should be entered on the pre-field form.

U. S. Bureau of Mines
AML INVENTORY FORM
EVALUATOR J. DOE
DRAFT
Part I - Pre-Field Data (Side 1)
PAGE 1 OF
SITE NUMBER ϕ16ϕ799ϕ3
DATE OF INVESTIGATION 9/25/95

1) PROPERTY NAME: Grizzly Bear
Alternate Names Bear Mine, Grizzly #1, 2, Grizzly
MILS Sequence No. ϕ16ϕ799203
MRDS No. WO195ϕϕ
BOM Mineral Property File No. 99.9
State ID No.
EPA ID No.

2) OWNERSHIP: What is the current ownership of the site? Check one.
Federal ☐ Indian ☐ State ☐ County ☐ Municipal ☐ Private/Patented ✓
Unknown ☐ Other
If the owner is known, fill in the following information.
Name or Agency Black Bear Mining Company
Address Colorado
Telephone Number — - — - —
Ownership includes Surface only ☐ Minerals only ☐ Both ☐

3) LOCATION DATA: Fill in location information as available.
State Idaho County Shoshone
Township ϕ4B (N) S Range ϕϕ2 (E) W Section ϕ2
Section Subdivision NWSENE Meridian Boise
Latitude N47°ϕ4'27" Longitude W116°14'45"
UTM Zone 11 Northing 5277166 Easting 556613
Elevation 1ϕϕϕ Specify units for elevation. Feet ☐ Meters ☒
Map Name Kellogg Map Scale 15 MIN
1:250,000 Quadrangle Spokane
Mining District Yreka
Approximate area of site Measured in Square feet ☐ Acres ☐ Hectares ☐

4) HISTORICAL DATA: Check all that apply.
Type of Operation:
Surface ☐ Underground ☒ Surface-Underground ☐ Mineral Location ☐ Placer ☐
Prospect ☐ Dredge ☐ Processing Plant ☐ Well ☐ Unknown ☐ No Data ☐
Status of Operation:
Past Producer ☒ Explored Prospect ☐ Raw Prospect ☐ Unknown ☐
Developed Prospect (greater than 300 meters of workings) ☐

**Figure 15.–AML data inventory form (pre-field section only)**

U.S. Bureau of Mines

AML INVENTORY FORM EVALUATOR J. DOE DRAFT

Part I - Pre-Field Data (Side 2) PAGE 2 OF

SITE NUMBER 04604792003 DATE OF INVESTIGATION 9/25/93

4) HISTORICAL DATA (Continued.) Check all that apply.

Commodities:

Arsenic ☐ Cadmium ☐ Copper ☒ Lead ☒ Mercury ☐ Zinc ☒

Other (specify) Gold, Silver

Commodity Groups:

Metals ☒ Coal ☐ Oil and Gas ☐ Uranium or Geothermal ☐

Industrial Minerals ☐ Sand and Gravel ☐ Non-Energy Leasable ☐

Other (specify)

Acid Producers or Indicator Minerals:

Arsenopyrite ☒ Chalcopyrite ☒ Galena ☒ Marcasite ☐ Sphalerite ☒ Sulfide ☒

Iron Oxide ☐ Limonite ☐ Pyrite ☒ Pyrrhotite ☒ Stibnite ☐

Size/Production: Indicate the total amount of ore produced to date in metric tons (mt).

Small (0-10,000 mt) ☐ Small-Medium (10,000mt-250,000mt) ☐ Medium (250,000mt-500,000mt) ☐

Medium-Large (500,000mt-1,000,000mt) ☐ Large (Over 1,000,000mt) ☐

Mill Method:

Amalgamation ☐ Arrastre ☐ Gravity ☐ Crusher (only) ☐ Heap Leach ☐ Leach ☐

CIP (Carbon-in-Pulp) ☐ Cyanidation ☐ Stamp ☐ Flotation ☒ * Jig Plant ☐ Retort ☐

No Mill ☐ Unknown ☐

Neutralizing Host Rock:

Carbonate ☐ Dolomite ☐ Limestone ☐ Marble ☐ Micrite ☐ Sparite ☐

Workings/history: Indicate size, number, and type of mine openings, if available.

Intermittent Operations

Years of Operation: From 1912 To 1955

Annual Precipitation: Check one.

Less than 25 centimeters ☐ More than 25 centimeters ☒

5) SPECIALTY DATA: Check all that apply.

Site in a known or suspected floodplain:

None ☐ Annual - 10 years ☐ 10 - 100 years ☐ 100 - 500 years ☐ Less than once every 500 years ☐

Threatened and Endangered Plants and Animals:

a) Are any threatened and/or endangered plants and/or animals on or near the site? Circle one. YES NO

b) If present, list type(s).

No T&E flora or fauna observed.

COMMENTS:

* Assumed flotation based on commodities.

Figure 15.–AML data inventory form (pre-field section only).–Continued

DATE GENERATED: APR 27, 1993

MINERALS AVAILABILITY SYSTEM
DEPOSIT LISTING

PAGE 1

1 — DEPOSIT NAME: GRIZZLY BEAR

1 — SEQUENCE NUMBER: 0160799203

>>>> MILS - TABLE <<<<
(GENERAL LOCATION INFORMATION)

3 — STATE: IDAHO
3 — COUNTY: SHOSHONE
4 — TYPE OF OPERATION: UNDERGROUND
CURRENT STATUS: PAST PRODUCER
3 — LATITUDE: N 47DEG 40MIN 22SEC
LONGITUDE: W 116DEG 14MIN 45SEC
UTM - ZONE: 11
HEMISPHERE: NORTHERN
NORTHING: 5279988
EASTING: 556613
POINT OF REFERENCE: MAIN ENT
PRECISION: 100 METERS
3 — ELEVATION: 1000 METERS
PRECISION: 10 METERS
PROPERTY FILE REPORT DATE:

3 — YEAR FIELD CHECKED: 1990
3 — QUADRANGLE: SPOKANE

MILS EVALUATOR: KAUFFMAN

DATUM OF ELEVATION: SEA LEVEL
3 — MAP NAME: KELLOGG
3 — SCALE: 15 MIN
DOMAIN: PRIVATE
2 — TYPE OF MINERAL HOLDINGS:
LOCATED CLAIM
PATENTED

MINE MAP REPOSITORY: W
TYPE OF EVALUATION: L
DATE LAST REVIEWED:
YEAR OF INFORMATION ENTRY: 1993
MAINTAINING FIELD CENTER:
WESTERN
MINERAL PROPERTY FILE: 99.9

MINES IDENTIFICATION:
GEOLOGICAL SURVEY SYSTEM: W019500
DATE LAST MODIFICATION:
APR 27, 1993
LAST DEPOSIT MODIFICATION:
APR 27, 1993
CONTRACTOR:

--PUBLIC LAND SURVEY--

PRINCIPAL MERIDIAN: 3
BOISE
TOWNSHIP: 048 N
RANGE: 002 E
SECTION: 02
SECTION SUBDIVISION:
NWSENE
SURVEY STATUS: SURVEY
---
TYPE OF PLANT:
PLANT IDENTIFIER:
MLA STUDY AREA: NO

PREDOMINANT MINING METHOD

4 — PREDOMINANT MILLING METHOD

PREDOMINANT POST MILL PROCESSING METHOD

(GEOGRAPHICAL INFORMATION)

3 — MINING DISTRICT: YREKA
*DISTANCE OF ROAD NEEDED: NONE
*DISTANCE TO ADEQUATE WATER SUPPLY: SITE
*DISTANCE TO ADEQUATE ELECTRICAL POWER SUPPLY: SITE
TOPOGRAPHY: V RUGGED
4 — ANNUAL PRECIPITATION (IN CM) AND DISTRIBUTION: 90.0 :WINTER
*(IN KILOMETERS)

VEGETATION: CONIFERS
SOIL TEXTURE: UNKNOWN
PRIMARY LAND USE: MINERAL
WORKING SEASON: ALL YR
LABOR AVAILIBILTY: UNKNOWN
CLIMATE: COOL

(HISTORICAL INFORMATION)

DISCOVERY METHOD:

YEAR OF DISCOVERY: 1900

YEAR OF INITIAL PRODUCTION: 1912

YEAR OF LAST PRODUCTION: 1955

>>>>> COMMODITY - TABLE <<<<<

| RECORD NUMBER | COMMODITY | MODIFIER | MARKETABILITY | COMMODITY CLASSIFICATION CODE | INDUSTRY REPORT CODE | STANDARD INDUSTRIAL CODE | S A S | DATE OF LAST MODIFICATION |
|---|---|---|---|---|---|---|---|---|
| 01 | LEAD | SULFIDE | RECOVERABLE | SULFIDE/SULFATE | METALLIC | | | APR 27, 1993 |
| 02 | ZINC | SULFIDE | RECOVERABLE | SULFIDE/SULFATE | METALLIC | | | APR 27, 1993 |
| 03 | SILVER | | RECOVERABLE | ELEMENT | PRECIOUS METALS | | | APR 27, 1993 |
| 04 | COPPER | SULFIDE | | SULFIDE/SULFATE | METALLIC | | | APR 27, 1993 |
| 05 | GOLD | LODE | | ELEMENT | PRECIOUS METALS | | | APR 27, 1993 |

4 —

>>>> NAMES(ALTERNATE) - TABLE <<<<

1 —

| | |
|---|---|
| 01 | BEAR MINE |
| 02 | GRIZZLY NO. 1 AND NO. 2 |
| 03 | GRIZZLY |

**Figure 16.–MILS printout showing supplementary data.**

DATE GENERATED: APR 27, 1993

DEPOSIT NAME: GRIZZLY BEAR

MINERALS AVAILABILITY SYSTEM
DEPOSIT LISTING



SEQUENCE NUMBER: 0160799203

>>>> OWNERSHIP - TABLE <<<<

| RECORD NO. | NAME OF OWNER | STATUS | PERCENT OF OWNERSHIP | LOCATION OF HOME OFFICE | YEAR OF INFORM. | DATE OF LAST MODIFICATION |
|---|---|---|---|---|---|---|
| 01 | BLACK BEAR MINING COMPANY | UNKNOWN | % | USA COLORADO | 1975 | APR 27, 1993 |



**Figure 16.–MILS printout showing supplementary data.**--Continued

DATE GENERATED: APR 27, 1993 MINERALS AVAILABILITY SYSTEM PAGE 3
DEPOSIT LISTING
DEPOSIT NAME: GRIZZLY BEAR SEQUENCE NUMBER: 0160799203

>>>> HISTORY OF EXPLORATION <<<<

| RECORD NO. | METHOD EMPLOYED | EXTENT EMPLOYED | SUPPORT OF EVALUATION | YEAR OF WORK | STATUS | YEAR OF INFORMATION |
|---|---|---|---|---|---|---|
| 01 | GEOCHEMICAL | | | 1971 | PRIOR TO | 1975 |
| 02 | TRENCHING | | | 1949 | | 1975 |
| 03 | CORE DRILLING | | | 1949 | | 1975 |

>>>>> GEOMETRY - TABLE <<<<<

MATRIX NUMBER: 1 COLUMN NUMBER: DATE LAST MODIFICATION: APR 27, 1993

| TYPE OF ORE BODY | SHAPE OF ORE BODY | TYPE OF WALLROCK ALTERATION | DEGREE OF WALL-ROCK ALTERATION | MODE OF ORIGIN | ORE CONTROLS |
|---|---|---|---|---|---|
| REPLACEMENT | TABULAR | BLEACHING | MODERATE | METAMORPHISM | FAULTING |
| FISSURE VEIN | | SERICITIC | | HYDROTHERMAL | FRACTURING |
| SHEAR ZONE | | | | | |

STRIKE AND DIP OF MINERALIZED ZONE: N65W:75S

| DEPTH TO MINERALIZATION (IN METERS) | | THICKNESS OF UNCONSOLIDATED MATERIAL (IN METERS) | | AVERAGE DIMENSIONS OF MINERALIZATION (IN METERS) | | SURFACE AREA | |
|---|---|---|---|---|---|---|---|
| AVERAGE: | | AVERAGE: | | LENGTH: | 458.0 | TOTAL: | |
| MINIMUM: | .0 | MINIMUM: | .0 | WIDTH: | 610.0 | FUTURE: | |
| | | | | THICKNESS: | 305.0 | PREVIOUS: | |
| | | | | | | RECLAIMED: | |

>>>>> LITHOLOGY - TABLE <<<<<

MATRIX NUMBER: 0 RECORD NUMBER: 1

FORMATION NAME: INTRUSIVE DIKES
AGE OF FORMATION: TERT
DENSITY (IN SITU):

RELATIONSHIP OF MINERALIZATION TO DEFORMATION: UNKNOWN
DEFORMATION DESCRIPTION: UNKNOWN
AGE OF DEFORMATION:



**Figure 16.–MILS printout showing supplementary data.**--Continued

DATE GENERATED: APR 27, 1993

MINERALS AVAILABILITY SYSTEM
DEPOSIT LISTING

PAGE 4

DEPOSIT NAME: GRIZZLY BEAR

SEQUENCE NUMBER: 0160799203

>>>>> LITHOLOGY - TABLE <<<<<

MATRIX NUMBER: 0 RECORD NUMBER: 9

FORMATION NAME: PRICHARD FORMATION
AGE OF FORMATION: PRECAM
DENSITY (IN SITU):

RELATIONSHIP OF MINERALIZATION TO DEFORMATION: COMPLEX
DEFORMATION DESCRIPTION:
AGE OF DEFORMATION:

>>>>> MINERALS - TABLE <<<<<

| MAT # | REC NO. | AGE OF MINERALIZATION | OVERALL GRAIN SIZE | NAME | CLASS | GRAIN SIZE | AMOUNT | UNITS |
|---|---|---|---|---|---|---|---|---|
| 4- | 01 | >CRET | VARIABLE | SPHALERITE | SULFIDES | | | |
| | 02 | >CRET | VARIABLE | GALENA | SULFIDES | | | |
| | 03 | >CRET | VARIABLE | CHALCOPYRITE | SULFIDES | | | |
| | 04 | >CRET | VARIABLE | PYRRHOTITE | SULFIDES | | | |
| | 05 | >CRET | VARIABLE | ARSENOPYRITE | SULFIDES | | | |
| | 11 | >CRET | VARIABLE | PYRITE | SULFIDES | | | |
| | 12 | >CRET | VARIABLE | SIDERITE | CARBONATES | | | |
| | 13 | >CRET | VARIABLE | ANKERITE | CARBONATES | | | |
| | 14 | >CRET | VARIABLE | QUARTZ | FORMS OF SIO2 | | | |
| | 15 | >CRET | VARIABLE | CALCITE | CARBONATES | | | |

>>>>> BIBLIOGRAPHY - TABLE <<<<<

| SET REFERENCE LINE NO. | |
|---|---|
| 001 | ARNOLD,COLEMAN,FRYKLUND 1962 ECON GEOL V 57 NO 8 P 1163-1174 |
| 002 | US BUREAU OF MINES INFO CIRC 7560 BUTNER 1950 11P |
| 003 | FRYKLUND (WITH A SECTION BY WEIS) 1964 USGS PROF PAPER 445 |
| 004 | JONES 1920 USGS BULL 710-A P 1-36 |
| 005 | UMPLEBY AND JONES 1923 USGS BULL 732 156P |
| 006 | FORRESTER 1945 USGS OP-FILE MAPS: MAPS OF HIGHLAND-SURPRISE |
| 007 | FORRESTER AND NELSON 1945 USGS OP-FILE REP: PB-ZN DEP PINE C |
| 008 | FRYKLUND AND HARNER 1955 ECON GEOL VOL 50 NO 3 P 339-344 |
| 009 | HOBBS AND OTHERS 1965 USGS PROF PAPER 478 |
| 010 | SHANNON 1923 US NATL MUSEUM BULL 131 P 98-100 |



**Figure 16.–MILS printout showing supplementary data.**--Continued

## Task 4—Establish a Computer File

If the geographic area of interest is expansive and includes a large number of mines, mills, and prospects, it will be useful to establish a computer file to store and manipulate the collected data. As will be seen in forthcoming sections, the quantity of data required in the pre-field and post-field screening processes could be difficult to handle using only manual methods. A number of commercial software packages for spreadsheets and relational databases such as Lotus 1-2-3, Quattro Pro, dBASE III, among others, are available and are well suited for applications of this nature. Refer to Step II for the names and types of data fields that should be established as part of Task 4. Information from MILS and the maps, which was entered on the pre-field form, now should be entered in the appropriate computer records.

## Task 5—Literature Search

Next, a literature search should be conducted using the information compiled in Tasks 1-4. Literature search, as used here, includes the acquisition of written materials, maps, photographs, remote sensing data, mining district information, and other materials relating to the site, area, or region. The object of the search is to verify as much of the previously acquired data as possible within established time constraints, and to obtain additional or more current information not available through the topographic maps or MILS. The results will be used as input to the data filter or screening process described in Step II in the next section. In addition to providing filter input, the search may reveal additional sites not identified when compiling the initial inventory. If this occurs, a pre-field form should be initiated for the property and an appropriate computer record established. For the reader's convenience, the types of information an AML investigator should look for in a literature search are summarized below. The summary in part reiterates those critical elements shown on the pre-field form as well as other information that may have a direct or indirect effect on the filter process described in Step II.

1. Property name and any other alternate or former names.
2. Location (PLS, latitude and longitude UTM coordinates).
3. Map names and scales.
4. Type of operation (surface, underground, surface/underground, quarry, open-pit, heap leach, vat leach, placer, or other).
5. Status of property (past producer, developed deposit, explored prospect, unknown).
6. Mineral commodity(ies).
7. Host rock type, particularly if limestone or other predominately calcareous (calcium-bearing) rock type.
8. Ore production (metric tons/year). Production data are not reported in MILS.
9. When was mine/mill in operation?
10. Type of ore body (fissure vein, disseminated, stockwork, placer, massive sulfide, etc.).
11. Commodity mined (gold, silver, copper, lead, zinc, mercury, etc.).
12. Ore minerals–particularly sulfides.
13. Is pyrite (iron sulfide) present on-site?

On completion of Step I the AML investigator has acquired the data to proceed to Step II in which they will be screened to produce a ranked listing of AML sites within the area of interest.

## STEP II–SELECTING SITES FOR FIELD INVESTIGATION

It is not economically feasible nor is it practical to examine all sites identified during the AML identification process. The purpose of Step II is to provide a methodology to systematically rank sites with respect to their hazard potential. The product of this exercise identifies those sites that should be given first consideration for further investigation, including possible field examination. These sites are identified by numeric hazard values assigned to them. The values are based on hazard factors which are assigned to selected fields of a computer spreadsheet or database. The hazard factors are determined from data in MILS or other sources of information. Table 2 lists all fields that will be required. Discussions later in the Task portions of this section will provide instructions for data input to the new fields.

**Table 2.–Suggested field names and spreadsheet structure (types and lengths) for fields used in site hazard rating and priority listing**

| General name | Field acronym | Field type | Field length |
|---|---|---|---|
| SEQUENCE NUMBER | **SEQ** | C | 10 |
| COMMODITY1 | **COMMO1** | C | 10 |
| COMMODITY2-6 | **COMMO2-6** | C | 10 |
| STATUS | **CUR** | C | 12 |
| PROPERTY TYPE | **TYP** | C | 12 |
| ORE PRODUCTION | **PROD** | C | 36 |
| HOST ROCK | **HOST** | C | 10 |
| ORE MINERALS | **OREMIN** | C | 42 |
| NON-ORE MINERALS | **GANGUE** | C | 42 |
| SIZE PRODUCTION | **SIZE** | C | 12 |
| MILL TYPE | **MILLTYPE** | C | 12 |
| ANNUAL PRECIPITATION (in cm) | **PPTN** | C | 3 |
| ACID POTENTIAL | **ACIDPOTL** | L | 1 |
| HUMAN HAZARD VALUE | **HHAZVAL** | N | 5 |
| ENVIRONMENTAL HAZARD VALUE | **EHAZVAL** | N | 5 |
| HAZARD RATING OVERALL | **HAZRATE** | N | 5 |
| PHYSICAL HAZARD VALUE | **PHAZVAL** | N | 5 |

C Character.
L Logical.
N Numeric.

**Note.–Do not confuse values calculated or determined for the "Overall Hazard Rating" in the following tasks with the EPA Hazard Ranking System of Superfund (CERCLA) hazardous waste sites.** The priority listing/ranking system in this methodology uses numbers representing "hazard factors" that are empirical in nature. The factors are based on arbitrarily selected values reflecting the professional opinions of how mine/mill characteristics may relate to potential hazards. These values represent the "perceived relative hazard potential" of a specific site characteristic. In essence, this procedure is a common sense approach that uses a numerical system for comparing mineral sites.

For example, the potential for hazards at a large mine would be greater than at a smaller mine. A mine with an on-site mill would have a greater hazard potential than one without a mill. A mill that used cyanide or mercury amalgamation for commodity recovery would have a higher hazard potential than a simple heavy-media separation process. The end number or "Overall Hazard Rating" represents a ranking for potential hazards to aid the investigator in the selection of sites for actual field investigation.

As previously discussed, there are two hazard types: Environmental (or chemical) and physical. Although this methodology is designed to identify and rank the chemical hazard potential of past mine activities, it can also be used, with modification, to assign a relative physical hazard value to each mineral site. The modifications necessary to rank sites by potential physical hazard are discussed at the end of Step II. This methodology subdivides chemical hazards into two categories, human and ecology (environment). Chemical conditions often pose a different hazard risk to humans than to flora and fauna. The difference in risk hazards between human and ecology stems from the chemical risks and properties intrinsic to differing elements/commodities. For example, the commodity asbestos poses a carcinogenic risk to humans but poses a lesser risk or concern to the ecology. Table E-1, appendix E, lists commodities with their respective human and ecology risk factors.

A computer "spreadsheet" software program such as Lotus 1-2-3 or Quattro/Quattro Pro is recommended for hazard value calculation. It is assumed that the reader either has knowledge or personnel resources available with a fundamental knowledge of spreadsheet software operations. Unless the number of mineral sites of concern is relatively small, manual calculation and ranking of sites by hazard value is time consuming. Although the mathematics entails simple multiplication of hazard factors, it is often necessary to make several iterations of the calculations as data fields are updated with new or additional information. The computer serves this process well.

The process of calculating potential hazard values and priority listing/ranking mineral sites begins when literature and information searches have been completed, Part 1 of the AML Inventory Form has been completed, and, if desired, mineral site data entry into a computer file has been completed. This process for chemical site priority listing is discussed in Task 1 through 5. Spreadsheet modifications necessary for calculation of potential physical hazard values are discussed in Task 6.

### Task 1–Spreadsheet Field Selection and Completion of Existing Fields

A spreadsheet template may be obtained from the Bureau's Western Field Operations Center, E. 360 Third Avenue, Spokane, WA 99202, telephone (509) 353-2700, facsimile (509) 353-2661.

Ensure that the following spreadsheet fields are defined and the data have been entered manually or extracted from a computer data file and imported into the spreadsheet. The data should be verified to the maximum extent practical:

- Site number (**SEQ**)
- Property name (**NAM**)
- Commodities, up to 6 (**COMMO1**, **COMMO2**, . . . **COMMO6**)
- Status (**CUR**)
- Property type (**TYPE**)
- Ore production (**PROD**)
- Mill method (**MILLTYPE**)
- Ore minerals (**OREMIN**)
- Non-ore minerals (**GANGUE**)
- Host rock (**HOST**)
- Precipitation (**PPTN**)

### Handling Insufficient/Lacking Data

The four most important fields of information for mineral sites in the "site-ranking process" are commodity, status, size, and mill type. A thorough literature search should provide adequate data for significant past producing mines. In those rare instances where one does not have data for one or more of these key fields, one should enter a code such as **"ERR"** in the field. This code will serve as a flag for additional scrutiny. In actual practice, many properties lacking data for these fields will be small and insignificant. In other words, they have never warranted a writeup with regard to their historical and geological significance. In most instances it may be appropriate to assume these properties have default values such as **STATUS** equal to "raw prospect," or "explored prospect;" **SIZE** equal to "small;" and **MILLTYPE** equal to "none." For **COMMO1**, assign the single most significant commodity for the mining district within which it lies or to which it is adjacent.

### Task 2--Determination of "Size" and "Acid Potential"

SIZE (**SIZE**)--Enter the appropriate "size" code that best describes the property. The value for the **SIZE** field is developed from data contained in the "Ore Production" (**PROD**) field. Use table E-4, appendix E for the code that best describes the known or estimated ore production provided or described in the **PROD** field. For example, mines having past ore production of 7,700 mt and 123,000 mt would be classified and coded as "small" and "small-medium" in size, respectively.

Acid Potential (**ACIDPOTL**)--The presence of acid drainage from a mineral site poses a risk that is largely dependent on the availability of water or precipitation, presence of pyrite ("fool's gold"), and the absence of a neutralizing host/country rock. Pyrite is the principal mineral of a suite of minerals that provide sulfur in sulfuric acid drainage. Other acid-forming minerals include arsenopyrite and pyrrhotite. Pyrite is a very common mineral in sulfide mineral deposits. It is often not reported in the literature description of a mineral site, nor is its presence always easily observed, especially at a well-oxidized site. Table E-7, appendix E, provides a more complete list of ore and gangue minerals that either contribute to, or are indicators of, other potentially present acid formation minerals.

The yes (Y) or no (N) entry for field "Acid Potential" (**ACIDPOTL**) is determined by using the combined fields Ore Minerals (**OREMIN**), Non-Ore Minerals (**GANGUE**), Host Rock (**HOST**), and Annual Precipitation (**PPTN**).

The following procedure is used to provide the "Y" or "N" entry into the field "Acid Potential" (**ACIDPOTL**):

- If fields **OREMIN** or **GANGUE** contain any minerals listed in the lookup minerals list provided in table E-7, appendix E, and
- the host or country rock name listed in the database field **HOST** does not appear in the lookup list provided in table E-8, appendix E, and
- the local annual precipitation in the field **PPTN** is greater than 25 cm, enter "Y" for the potential for acid drainage.
- If not "Y", then enter "N" for no or little acid mine drainage risk. For example, using fields **OREMIN, GANGUE, HOST, PPTN**, and tables E-7 and E-8, appendix E, the "acid potential" (**ACIDPOTL**) for a deposit having a lead-zinc vein with limonite gangue in a granodiorite host where precipitation was greater than 25 cm/yr would be "Y" (yes). The same situation above with either a limestone host or low annual precipitation (less than 25 cm/yr), or no ore/gangue minerals listed in table E-7, appendix E, would have the value of "N" (no) in the **ACIDPOTL** field.

## Task 3—Calculation of Chemical Hazard Values: Human, Environmental, and Overall

This task uses numerical hazard factors assigned to field codes listed in tables E-1 through E-6 in appendix E to calculate hazard values. Calculated values using these factors will be entered into additional fields of the spreadsheet. The final "Hazard Rating Overall" is equal to the higher of the two calculated value entries for **HHAZVAL** and **EHAZVAL**.

### Calculation Steps

(1) To calculate the "Human Hazard Value" (**HHAZVAL**) for each mineral site, first use fields **COMMO1** through **COMMO6** and select the highest "Human" factor for those commodities. Multiply this "human commodity factor" by all other hazard factors for the mineral site found in tables E-2 through E-6 of appendix E. The calculated value is entered and stored in the field **HHAZVAL**. Simply stated, the calculation is: (Highest Human Commodity Hazard Factor) x (Status Hazard Factor) x (Property Type Hazard Factor) x (Production Size Hazard Factor) x (Mill Type Hazard Factor) x (Acid Potential Hazard Factor) = **HHAZVAL**.

(2) Calculate Environment Hazard Value (**EHAZVAL**) in a similar manner. The highest "Environmental" hazard factor is chosen from table E-1, appendix E for the commodities occurring at each mineral site and is in turn multiplied by hazard factors for the field values describing each mineral site in tables E-2 through E-6, appendix E. The result is entered and stored in field **EHAZVAL**.

(3) The higher of the two values of fields **HHAZVAL** and **EHAZVAL** is entered in the field **HAZRATE** as the overall hazard potential of the mineral site.

## Task 4--Ranking and Priority Listing

The process of "ranking," as defined in this methodology, is the ordering or relative positioning of values with respect to other values in the same group. This process is simple and fast when done using the sorting features of a spreadsheet. Basically, one selects a field such as **HHAZVAL**, **EHAZVAL**, or **HAZRATE**, sorts the data, and lists mineral sites numerically from the highest hazard potential to the lowest.

A priority listing is the task wherein managers/investigators must decide what to do with the ranked sites. The primary decision to be made is whether to conduct site examinations, and, if so, which sites? Prioritization is in part a subjective action because it involves decisions based on agency goals, time, budgets, remoteness, data integrity, risk levels, etc., and not scientifically established rank/action criteria. For example, the decision may be to examine "the potentially worst 10 pct" or "those that rank above a certain natural break in the rankings" or "sites within 30 km of a population center" or " those that can be examined by 1 person in 2 months."

### Examples

**Example 1:**

A. The Blue Bell Mine (fictitious) is a replacement deposit in limestone country rock. It produced 36,000 mt ore from 1932 to 1946. The deposit is accessed by two adits and has more than 1,100 m of underground workings. Ore minerals include chalcopyrite and sphalerite. Associated gangue minerals are pyrite, arsenopyrite, calcite, and siderite. Copper and zinc concentrates were produced in an on-site mill using flotation methods. The area has an annual precipitation rate greater than 60 cm/yr.

B. Calculation of human and environmental hazard values

1. Field entries and codes will be:

| | | |
|---|---|---|
| Commodity | = "arsenic" with human hazard factor | = 7 |
| | "copper" with environmental hazard factor | = 5 |
| Status | = past producer--hazard factor | = 2 |
| Property type | = underground--hazard factor | = 1.2 |
| Size | = small-medium--hazard factor | = 1.4 |
| Mill method | = flotation--hazard factor | = 2.2 |
| Acid potential | = n--hazard factor | = 1 |

2. Calculations: (involves multiplication of field code hazard factors)
   Equation hazard values: Commodity x Status x Type x Size x Mill Method x Acid Potential
   Human hazard values (HHAZVAL): (7)x(2)x(1.2)x(1.4)x(2.2)x(1) = 51.7
   Environmental hazard value (EHAZVAL) = (5)x(2)x(1.2)x(1.4)x(2.2)x(1) = 37.0
   Overall hazard rating (HAZRATE): = 51.7

C. Comments: The commodity arsenic is from the gangue mineral arsenopyrite. The human hazard factor for arsenic was used as a human hazard as it had a higher value than either copper or zinc. One should also consider the possibility of the presence of the commodity "cadmium," a common byproduct

of sphalerite. Acid production is not a concern (hazard value of 1) as the host rock is limestone, a neutralizing agent. Overall hazard rating is equal to the higher value of the two values calculated for human and environmental.

Example 2:

A. The Pioneer Mercury Mine (fictitious) produced three flasks of mercury in the early 1920's from an estimated 10 mt of ore. The property consists of two small pits in a volcanic host. Ore minerals include cinnabar and free mercury. The area is dry desert, and precipitation is less than 25 cm/yr. No mill is present.

B. Calculation of human and environmental values

1. Field entries and codes will be:

| | | |
|---|---|---|
| Commodity | = "mercury" with human hazard factor | = 9 |
| | "mercury" with environmental hazard factor | = 6 |
| Status | = past producer--hazard factor | = 2 |
| Property type | = surface--hazard factor | = 1.2 |
| Size | = small--hazard factor | = 1.2 |
| Mill method | = no mill--hazard factor | = 1 |
| Acid potential | = no--hazard factor | = 1 |

2. Calculations:

Human hazard value (**HHAZVAL**) = (9)x(2)x(1.2)x(1.2)x(1)x(1) = 25.9

Environmental hazard value (**EHAZVAL**) = (6)x(2)x(1.2)x(1.2)x(1)x(1) = 17.3

Overall hazard rating (**HAZRATE**) = 25.9

C. Comments: Based on data obtained from pre-field literature search and contained in the narratives, values for the hazard potentials calculated for Example 1 are higher than Example 2. If these examples were two among many other mineral sites studied and potential hazards calculated, one would compare these site hazard values with others. Comparison is more easily done by ordering/ranking sites by the **HAZRATE** value from high to low. The sites with the highest overall hazard ratings could be the first ones scheduled for on-site investigation.

## STEP III–CONDUCTING A SITE INVESTIGATION

Step III in the AML inventory/investigation process is to prepare for the site examination and then prepare a record of the apparent potential environmental, public safety, and reclamation hazards on-site. The ultimate purpose of this work is to gather information necessary to identify sites that require future action and to gain an insight of the magnitude of environmental or physical hazards, or reclamation problems, if they are present. Documentation developed at a given site may represent the only information available on the site, and represent the sole basis for a decision as to whether additional expensive, detailed work is necessary; thus, accuracy is imperative.

To accomplish this step, both environmental and physical potential hazard information is recorded. The process is divided into two groups of tasks: (1) preparation for the site investigation; and (2) conducting the site investigation. Work in both groups is based on the assumption that results from Step I and Step II have been assembled into a usable format. The tasks for Step III are summarized below by each group and are discussed in detail in later sections.

Group 1 - **Preparing for Site Investigation**

Task 1. Determine access routes.
Task 2. Obtain necessary training.
Task 3. Obtain necessary equipment.
Task 4. Prepare travel itinerary.

Group 2 - **On-Site Investigation**

Task 1. Travel.
Task 2. Start site examination process.
Task 3. Review the AML Inventory Form.
Task 4. Complete the field form.
Task 5. Review form for completeness.
Task 6. Review all sets of data for completeness.

### Group 1–Preparing for Site Investigation

#### Task 1–Determine Access Routes

Access can be one of the most critical parts of planning. Use the small-scale maps prepared previously to develop general access and logistics plans for a given area of work. Large-scale maps mentioned previously are used to determine the access to specific sites or groups of sites. During this process, note carefully the type of roads available and their description in the map explanation. Dashed roads or "Jeep Roads" are often rough to rugged and may require a 4-wheel drive vehicle and a driver with 4-wheel drive experience (see appendix G for suggested training). Note areas of special significance such as creek and river crossings, rocky slopes, abrupt changes in slope, swampy areas, and sudden changes in vegetation (vegetation is often noted on the map in green; white generally denotes a lack of vegetation). These areas could represent danger spots. While driving to and from these areas also watch for ruts, gullies, side-hill road cuts, and other unusual conditions. USBM experience indicates that more accidents occur in transit to and from old mine sites than at the sites themselves, therefore, access planning and caution are critical.

### Task 2—Obtain Necessary Training

Proper training is critical in traveling to and from the sites as well as working at the sites. Appendix G lists suggested training courses available from a variety of sources. Specific individual training should be based on organization or agency requirements, individual need, and availability. Training may include vehicle operation, first aid, equipment operation, and hazardous materials.

### Task 3—Obtain Necessary Equipment

Another essential aspect of evaluation is appropriate equipment. Appendix H lists various recommended equipment for both vehicles and site evaluation. The AML Inventory Pre-field and Field Forms are both critical parts of this equipment, as is a "Polaroid" or other type camera and film. Prepare the vehicle, vehicle equipment, and personal equipment for fieldwork. Material from Tasks 1 and 2 of Step I also should be included.

### Task 4—Prepare Travel Itinerary

A travel itinerary and plan must be developed. This should include lodging locations, location of nearest emergency facilities, emergency telephones, and other agency-specific procedures. Safety is critical in all phases of this work. It is strongly recommended that people work in pairs when in areas of past mining activity.

## Group 2—On-Site Investigation

### General Field Investigation Philosophy

The goal of an on-site field investigation is to answer two questions: (1) does a problem exist, and (2) if so, how severe is the problem. A problem may be simple or complex in nature. Also, problem severity can be divided into "actual" and "relative" severity. For example, a 50-ft-deep shaft has a certain amount of danger irrespective of location (actual severity). However, it is more dangerous (relative severity) to humans if located near a popular hiking trail.

Effective field investigation is based on a good strategy developed well before entering the field. Upon arrival at a site, concentrate on the major or gross features, not the details. The details will be examined later if the site warrants further work. In general, look for indicators of both environmental problems and physical hazards.

To meet the stated goal, data must be collected on what is present, its condition, size, shape/depth, presence of certain metals, stability, and actual dangers. These data are collected through a series of questions presented in two groups on a field data form: site data and feature data. Site-wide potential problems vary considerably in severity, as do feature-specific problems. Thus the focus of the form from general to specific is to help the user focus on significant data. Each part of the field form leads one step-by-step through the data acquisition process and explains what specific items to look for or examine. Appendix I summarizes the feature groups, individual features, observations needed, and the meaning of each observation.

A brief field examination offers only limited choices of what to do if a problem is discovered. For most environmental physical hazards (e.g., an old barrel of chemicals), the only response is to note the problem on the form and follow agency-specific procedures for handling this type of situation. In a few cases the problem will be so severe that immediate response is necessary (e.g., a leaky drum of chemicals). In such cases, note the problem in the comments section at the bottom of the field form and handle according to agency policy. But, in general, subsequent detailed examinations will define the problems and aid in developing proposed solutions.

## Field Form

Mining, milling, and smelting are early phases of minerals acquisition and use (fig. 17) and operations range from small prospects to major facilities. This broad range gives an equally broad range of both physical and environmental problems. A standardized methodology is necessary to consistently determine the existence and severity of either category of problem at a given site. This is best accomplished with a standardized form. The form must be easy to use, gather all essential data, and be flexible enough to work with at any site examined. The example form presented in appendix C accomplishes these goals. The underlying strategy for site investigation is to minimize field data collection costs and maximize relevant data collection.

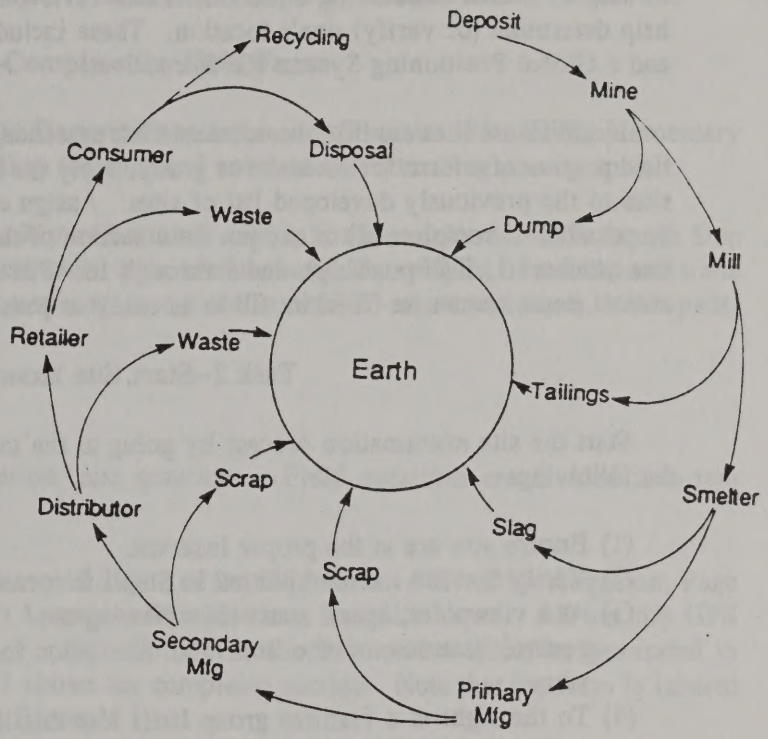



**Figure 17.–Minerals life cycle of discovery, processing, use, and disposal.**

The amount of time available to visit a given site is assumed to be very limited, generally one-half day, assuming one-half day for preparation and travel. That assumption is reflected in this field form. Notably:

- No sampling for chemical analysis of rock, soil, or water is required; indirect indicators will be used to determine if environmental problems exist, and
- Actual measurements will be restricted to pH, conductivity, radiation, and estimated dimensions.

As discussed earlier, the form has two major sections, pre-field and field. The field section, described here, is designed for both site and feature-by-feature evaluation and uses a single page form to inventory each significant mine- and mill-related feature. The form allows for the use of sketch maps and photos which results in a quick and easy field inventory system, and allows for future automated data and record storage and processing.

Site safety is a critical factor. **NEVER GO INTO AN UNDERGROUND MINE WITHOUT PROPER EQUIPMENT AND TRAINING.** It is also wise to stay out of buildings that appear unstable or are partly collapsed. The form is designed assuming that a person will NOT go into these areas.

### Task 1–Travel to the General Area/Conduct Reconnaissance

For Task I, the AML investigator travels to the general area where the site or group of sites is to be examined. A reconnaissance (a rapid perusal of the general area in which the sites are located) is advisable to determine if any additional sites are present that were not discovered in the pre-field studies of Step I. When conducting a reconnaissance review of an area, several items are of particular use to help determine (or verify) one's location. These include both large- and small-scale maps, a compass, and a Global Positioning System (GPS) receiver.

If additional sites are discovered, note their presence, location, and gross features. Complete the pre-field portion of a form for each site or group, apply the filter (as described in Step II), and add these new sites to the previously developed list of sites. Assign each new site a unique site number. It may not be possible to complete all of the pre-field section of the form at this time. Critical data fields include line numbers 1, 2 (if possible), and 9 through 16. Fill in any other data that are available. If all of the critical items cannot be filled in, fill in as many as possible and proceed to the next section.

### Task 2–Start Site Examination Process

Start the site examination process by going to the most important site first. Then, proceed through the following:

(1) Ensure you are at the proper location.
(2) Verify that the location plotted in Step I is correct.
(3) At a viewpoint, spend some time viewing the general features of the area and site prior to site entry.
(4) To the right is a features group list. Use this list to begin organization of the site investigation. Items are listed in the general order in which minerals pass through the mine/mill system.
(5) Conduct a general reconnaissance of the entire site. Carefully walk through and around the area to determine the size and nature of the site. See appendix I for details of site features, concerns, and actions.
(6) Prepare a sketch map of the general relative locations of the major features or feature groups.

Typical Groups of Features

1. Mine Openings Features
2. Mine Infrastructure
3. Mine Dmps
4. Mine Ore Stockpiles
5. Raised Structures
6. Mill Infrastructure
7. Mill Tailings
8. Leach Pads and Solution Ponds
9. Suspended Systems

### Task 3—Review the AML Inventory Form Parts I and II

Review the AML Inventory Form, Part I-Pre-Field Data, for completeness. If possible, fill in any blanks.

General site data should be collected and all significant features at a mine, mill, or related site must be documented. Review the Part II-Field Data form to devise a plan to collect both general site data and data on each feature identified. USBM experience indicates one of the best ways to collect site data is to work step-wise through the features groups. This assures completeness and reduces confusion.

### Task 4—Complete the Field Form

The AML Inventory Form, Part II-Field Data, is discussed in detail below. Part III-Supplementary Data, provides a gridded format for recording sketches and notes and for attaching photographs.

For example purposes, the Grizzly Bear Mine (fictitious) used in the discussion of MILS data in Step I will be used here. It has one open and one caved adit, a mine dump, the remains of a mill, and some mill tailings. The Grizzly Bear Mine does not contain any ore stockpiles, raised structures, leach pads, solution ponds, or suspended systems.

#### Form Heading

Each form has a title, header information, and questions. Field questions are divided into two sections, site related and feature related.

Five groups of information occur at the top of Side 1 of the field form: Date of Investigation, Page Number, Global Positioning System (GPS) Location, Site Number, and Site Name. All but the GPS location are repeated at the top of Side 2. For Site No., fill in the site number identifier generated in Step I, Task 3 in the blank box. Example 1 shows the completed section. Note that the form is labeled "Part II-Field Data (Side I) Site Data" (see Example 1).

A second group of questions at the top of Part II-Field Data (Side I) records agency specific information. Questions include: Evaluator, Agency, Address, and Telephone No. An example of completed questions is shown below.

INVESTIGATION DATE 4-28-93 PAGE 1 OF 3
GPS LOCATION N-5279169 E-556613
SITE NUMBER 0160799203 SITE NAME Grizzly Bear
EVALUATOR John DOE AGENCY USBM
ADDRESS E.360 3rd Ave, Spokane, WA TELEPHONE (509)353-2700

**Example 1.—Page heading information with completed items.**

## Form Sections

The first section of the form addresses site-related questions; the second section addresses feature-related questions. Complete one form for the site and one copy of Side 2 for each feature identified in question 10 at each site (see question 10 discussion). For example, if a site has two adits, two dumps, and a mine supply shed, complete one copy of Side 1 and five copies of Side 2. All five Side 2 pages would have the same site number, probably the same evaluator, and the same date, but different page numbers. For questions 1 through 9, answer each which pertains to the site under examination. If a question is not relevant, continue to the next question. For questions 10 through 18 answer each that pertains to the feature under examination. If a question is not relevant, continue to the next question.

A detailed explanation of questions 1 through 18 follows.

### Site Related Characteristics

### Question 1

The first question (see Example 2) is **NEAREST SITE(S) OF HUMAN ACTIVITY**. Give the distance and circle units or mark N/A (not applicable) for each item: dwelling, school, work place, campground, trail, or road. This information will be used to evaluate the relative danger of a given condition.

1) NEAREST SITE(S) OF HUMAN ACTIVITY (Give distance, circle units, or mark N/A)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Dwelling(s) | 5 | km (mi) | School | N/A | km mi | Workplace | N/A | km mi |
| Campground | N/A | km mi | Trail | N/A | km mi | Road | N/A | km mi |

2) SENSITIVE ENVIRONMENTS (If any, give name or distance, if known) Circle one per group

| | | | | |
|---|---|---|---|---|
| a) Threatened and Endangered Species | | (UNK) | YES | NO |
| b) Wetlands | km mi | UNK | YES | (NO) |
| c) Fisheries | km mi | (UNK) | YES | NO |
| d) Other | km mi | UNK | YES | (NO) |

**Example 2.**–Nearest sites of HUMAN ACTIVITY and SENSITIVE ENVIRONMENTS questions from field form, with example answers.

### Question 2

Question 2 (see Example 2) is **SENSITIVE ENVIRONMENTS**. Circle one, **Unk** (unknown) **Yes** or **No**. If the answer is yes, as appropriate, give the name of the "Threatened and Endangered" (T&E) species or the distance from the site to the wetlands, fisheries, or other sensitive environment. Circle proper units. A sensitive environment is one that may be adversely affected by the presence of heavy metals. The choices are: (a) T&E species; (b) Wetlands; (c) Fisheries; and (d) Other. For T&E species, local land managing agency offices are often a good source of information.

## Question 3

Question 3 (see Example 3) is **WATER**. Presence of water is a significant item to note. "Are bodies of water (i.e., rivers, lakes, etc.) found on or within 2 miles of the site?" Circle **Yes** or **No** and check all that apply; five choices are given, or, fill in the space labeled "Other."

In our example the Grizzly Bear Mine is near (less than 2 miles) Gold Creek; circle **Yes**, place an "X" in the box by "Stream," give the creek name and note the distance of 0.1 mile.

## Question 4

Question 4 (see Example 3) is **AIRBORNE POLLUTANTS**. Circle **Unk**, **Yes**, or **No** and mark all that apply. The choices include: Dust (as in blowing dust from a mill tailings pond), Spray (e.g., a leaky pipe), Vapor (e.g., an open barrel of chemicals), or Other (to be filled in as appropriate). Dust could carry heavy metals, if present, and contaminate surrounding areas. Spray or vapor could be hazardous locally.

In our example a small amount of dust from the mine dump is noted on a very windy day; circle **Yes** for dust as a precaution. There are no other visible airborne pollutants; all other answers are circled **No**.

3) WATER Are bodies of water found on or within 2 mi (3.2 km) of the site? Circle one, and check all that apply. YES NO

Stream [X] River [ ] Pond [ ] Lake [ ] Bay [ ] Other [ ]

Name of nearest water body [Gold Creek] Distance [0.1] km (mi)

4) AIRBORNE POLLUTANTS — Circle one per group

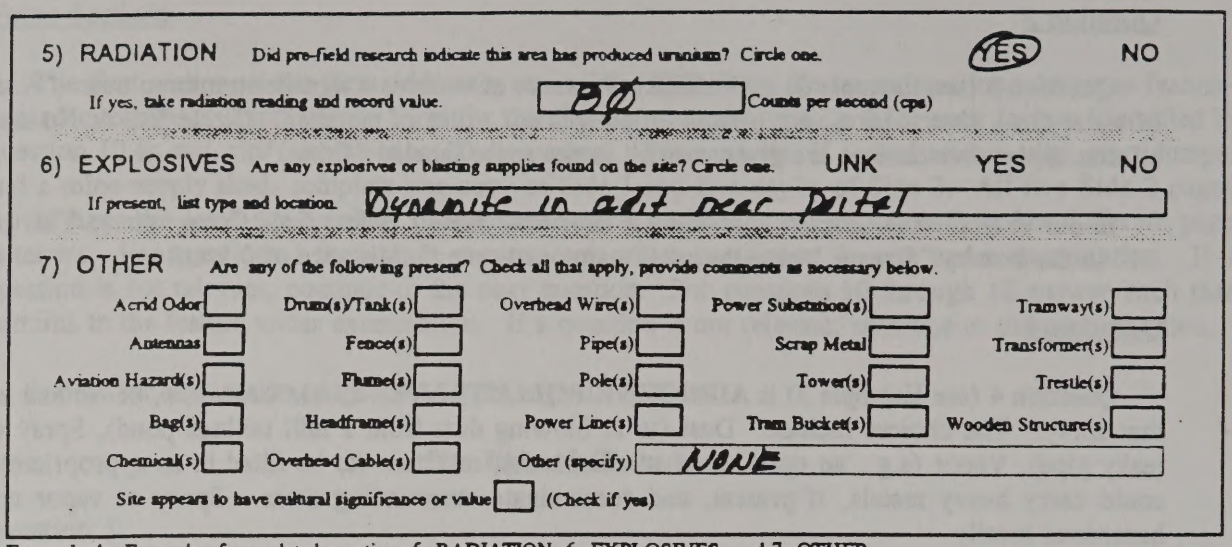
| | | | |
|---|---|---|---|
| a) Dust | UNK | (YES) | NO |
| b) Spray | UNK | YES | (NO) |
| c) Vapor | UNK | YES | (NO) |
| d) Other Name [ ] | UNK | YES | (NO) |

**Example 3.**–Example of completed question 3, WATER, and question 4, AIRBORNE POLLUTANTS.

## Question 5

Question 5 (see Example 4) deals with uranium and related radioactive minerals: **RADIATION**. Specifically, "Did pre-field research indicate this area has produced uranium?" Circle **Yes** or **No**. If pre-field data indicate that an area has uranium or has had uranium production, then line 19 on the pre-field form should be answered yes, and likewise this question is answered yes. So to answer this question, simply refer to line 19 on the pre-field form.

If the answer is yes, use a radiation meter to measure the amount of radiation (usually in counts per second [cps]) present at the site. Stand approximately 7 m (23 ft) away from the area in question to collect the reading. If collecting a reading from a mine dump or mill tailing, stand in the center of the exposed surface to collect a reading and so note on the form. Once collected, record the value in the box labeled "Counts per second (cps)."


5) RADIATION Did pre-field research indicate this area has produced uranium? Circle one. YES NO

If yes, take radiation reading and record value. 80 Counts per second (cps)

6) EXPLOSIVES Are any explosives or blasting supplies found on the site? Circle one. UNK YES NO

If present, list type and location. Dynamite in adit near portal

7) OTHER Are any of the following present? Check all that apply, provide comments as necessary below.

| | | | | |
|---|---|---|---|---|
| Acrid Odor | Drum(s)/Tank(s) | Overhead Wire(s) | Power Substation(s) | Tramway(s) |
| Antennas | Fence(s) | Pipe(s) | Scrap Metal | Transformer(s) |
| Aviation Hazard(s) | Flume(s) | Pole(s) | Tower(s) | Trestle(s) |
| Bag(s) | Headframe(s) | Power Line(s) | Tram Bucket(s) | Wooden Structure(s) |
| Chemical(s) | Overhead Cable(s) | Other (specify) | NONE | |

Site appears to have cultural significance or value (Check if yes)

**Example 4.**–Example of completed questions 5, RADIATION; 6, EXPLOSIVES; and 7, OTHER.

In the Grizzly Bear Mine example, it is not certain that the mine produced uranium. It is known, however, that the mine produced lead and zinc; but, an obscure comment was found during the pre-field work about a uranium prospect somewhere in the general area. It would be prudent to take a reading just to be sure. At a distance of 7 m (23 ft) from the adit entrance, a reading of 80 cps is received. Enter the data in the appropriate box to the right (see Example 4), and go to the next question.

## Question 6

Question 6 (see Example 4) is **EXPLOSIVES**. Specifically, "Are any explosives or blasting supplies found on the site?" Answer by circling **Yes**, **No**, or **UNK** (unknown). If present, list the type and location in the box provided. For this question, the explosives or blasting supplies do not have to be at the feature listed, but can be nearby. Be sure to note the location of such material.

**IF ANY EXPLOSIVES, BLASTING CAPS, OR SUPPLIES ARE PRESENT, DO NOT TOUCH!!!!**

In the Grizzly Bear example, a box of dynamite was seen near the entrance perched on a dry part of the floor (fig. 9). Note this on the sketch map and on the form. The beads on the dynamite (fig. 10) are nitroglycerine, which is VERY DANGEROUS AND MUST NOT BE TOUCHED. As shown in example 4, **Yes** is circled and "Dynamite in adit near portal" is written in the blank box.

## Question 7

Question 7 (see Example 4) is **OTHER** and applies to the entire site. Specifically, "Are any of the following present?" Place an "X" or check in the box beside all that apply, and provide comments as necessary in the comments section. The choices include: Acrid odor, drums, headframes, antennas, tramways, bags, scrap metal, wooden structures, overhead cables, overhead wires, pipe, flumes, trestles, power lines, tram buckets, poles, towers, power substations, transformers and fences. If there are items present that are not listed, fill in the box "Other." Also note, by marking the "yes" box, if the site appears to have cultural significance or value.

Several of the above items deserve supplemental definition: headframes are structures above a shaft to hold machinery used to lift ore; bags refers to large paper or fabric bags used to hold chemicals; poles refers to large cylindrical wood or metal objects used to support electrical wires, cables, or other devices.

If drums and bags are present, look for labels, but DO NOT handle or get too close. If labels are present and readable from a distance, note label information in the comments section.

In the Grizzly Bear Mine example, none of these items were noticed so the word "none" was placed in the box labeled "Other."

Question 8

Question 8 (see Example 5) is **PHOTOGRAPH NUMBERS**. This is a blank box to record all photo numbers for photos collected of this specific feature.

8) PHOTOGRAPH NUMBERS 0160799203, 1

9) SKETCH NUMBERS 1, 2

COMMENTS Mine water flows into nearby creek.

**Example 5.**—Sample of completed question 8, PHOTOGRAPH NUMBERS; question 9, SKETCH NUMBERS; and COMMENTS.

In the Grizzly Bear Mine example, one photograph was taken at the open portal feature. The photograph was labeled and assigned the number 0160799203-1. This number was written in the blank box of question 8.

Question 9

Question 9 (see Example 5) is **SKETCH NUMBERS**. In this box, record the numbers of each sketch map made of this particular feature and the sketch map which contains the location of this feature.

In the Grizzly Bear Mine example, a general reconnaissance sketch map was prepared and this adit feature was located on the reconnaissance map.

Comments

This box is provided to allow for discussion of anything not covered specifically in the form. Comments could include: road accessability of site, general geology, minerals present, and other special features.

In the Grizzly Bear Mine example, water was flowing from the adit. This water was traced to a location where it entered a nearby creek. The following note was entered in the comments section, "Mine water flows into nearby creek."

## Photography

A photograph is recommended to record a specific feature or condition. Use a "Polaroid" type camera for this purpose as it produces 'instant' pictures which can be numbered and labeled. A second camera of some other type also may be of use. Stand far enough away from the feature to photograph any pertinent aspect, including country rock and stains. In some instances closeup pictures may be best. Each photo should have a photo number (described below).

## Photo Numbering System

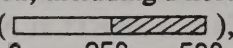
The photo numbering system used here is designed as a two-part system, specifically: first is the site number and second is the feature number; the two are separated by a dash. If more details are necessary, a letter prefix may be added to the feature number. For example, "A" for adit, "S" for shaft, etc.

Always place the site number and feature number, where appropriate, on each photo taken. This prevents confusion of photos among sites, should they become mixed.

BE SURE PHOTO NUMBERS ALWAYS ARE RECORDED ON AT LEAST ONE SKETCH MAP. WITHOUT THIS RECORDATION, THE EXACT LOCATION OF THE PHOTO IS UNCERTAIN.

## Sketch Map

Once the photos have been collected and numbers assigned, add the numbers to the initial sketch map prepared during the reconnaissance review. If items are too small on this map to allow for adequate detail, supplemental larger scale (covers a small area) sketch maps may be necessary and can be prepared for any part of the site. Place a rectangle on the initial map showing the areas where larger scale maps are situated. Place a supplemental map number inside the appropriate rectangle. See figures 18 and 19 (p. 58).

Each sketch map should contain certain information, including a north arrow, scale expressed in both narrative (1 in represents 500 ft) and as a scale bar ( 

), and the site number.

### Feature Related Characteristics

The next series of questions (10 through 18) refers to FEATURES. Complete one set of questions per feature. Prepare (photocopy) additional copies of this page for additional features at a given site.

## Question 10

Question 10 (see Example 6) is **FEATURE**. This question asks for the identification of the feature under examination. Use one sheet per feature. Twenty-five specific major feature items are listed with space to list additional features. Place a check mark or an "X" in the box beside the term which best describes the feature under examination, or fill in the box labeled "Other." Features are reviewed in appendix I. Remember, only one feature per form.

It is important to know the total number of significant features at any given site. Thus, each feature visited should be given a number. Start with the number one (1) for the first feature and enter this in the box labeled "Feature Number." For the second feature visited, enter the number two (2). Add these numbers to the sketch map.

Feature identification is significant in the definition of possible environmental or physical hazards.

Example 6 shows a portion of the field form in which question 10 has been completed. Using the example of the Grizzly Bear Mine, two adits are observed during site reconnaissance. The first adit chosen for examination is open to entry. For the features question, mark "adit." Because this is the first feature visited, enter the number one (1) in the box labeled "Feature Number."

## Question 11

Question 11 is **CONDITION**. For the identified feature, mark the phrase that best describes its condition, and determine if the condition of this feature represents a physical hazard. Circle **Yes** or **No**. Place a check or an "X" in the box beside the item that best describes the physical character of this feature. Choose from the list of 20 items or fill in the box labeled "Other." Accuracy of observation is critical because the answer will indicate what remediation is necessary. Most terms are self-explanatory. "Concealed" refers to the viewer's difficulty in seeing a feature. A pit fully overgrown with trees and bushes would be fully concealed. "Confined" refers to the presence of a retaining structure such as a tailings dam. "Subsidence" can refer to a depression around a wellhead, over a stope or glory hole, or broader area over a section of a mine, entire mine, or mining area.

In the Grizzly Bear example, question 11 (Example 6) is marked "Open to Entry." At the portal (entrance to the adit) some rocks have sloughed from the wall onto the floor of the adit. The presence of slough material is noted in the box labeled "Other." For this particular adit, accessibility implies relatively stable rock, but the slough material also implies some local weakness which could, in the future, represent a physical hazard; **Yes** is circled for the physical hazard question.

## Question 12

Question 12 (see Example 6) is **SIZE OF FEATURE**. For significant features, indicate the size, measurement quality, and units, especially if this would aid overall description. This question is most often applied to mine dumps and mill tails. A row of three boxes is provided. In the first box give the length, in the second box give the width, and in the third box give the depth or height. Place a check or an "X" in one of the two boxes marked "actual" or "estimate" to indicate the quality of measurement; place an "X" in one of the two boxes marked "feet" or "meters" to indicate the units of measurement. Size estimates are acceptable. In the case of features such as adits, place **N/A** (not applicable) in the box labeled length as the length will be unknown without entry; however, if the length can be estimated, include this datum. The length of adit can often be estimated by shining a light down the adit. Also replace the word "depth" with "height" if the height of the adit is to be recorded and circle the appropriate word on the form. This question is also useful for giving approximate extent of subsidence around solution mining wells, thin ground over mined-out areas, mine dumps, and mill tailings. For highwalls, fill in height, slope (in degrees), and stability.

For the Grizzly Bear example, the feature is an adit with measurements of 4 ft wide by 7 ft high. These data are entered in their respective boxes, and "N/A" is entered for "length." Because this is not a "highwall," "N/A" is entered for "slope" and for "stability."

10) FEATURE Number 1 Fill out one form per feature. Check appropriate box below.

| | | | | | |
|---|---|---|---|---|---|
| Adit [X] | Decline [ ] | Machinery [ ] | Ore Stockpile [ ] | Quarry [ ] | Slope [ ] |
| Building [ ] | Glory Hole [ ] | Mill Building [ ] | Pit, Large, >3 m [ ] | Shaft [ ] | Subsidence [ ] |
| Cistern [ ] | Highwall [ ] | Mill Tailings [ ] | Pit, Small, <3 m [ ] | Solution Mining Well [ ] | Sump [ ] |
| Crosscut [ ] | Leach Pad [ ] | Mine Dump [ ] | Placer Mine [ ] | Solution Pond [ ] | Trench [ ] |
| Other [ ] | | | | | Tunnel [ ] |

11) CONDITION Does the condition of the above identified feature represent a physical hazard? Circle one. YES NO

Check the conditions that best describe the physical character of the above feature.

| | | | | | |
|---|---|---|---|---|---|
| Breached [ ] | Collapsed, Partial [ ] | Empty [ ] | Foundation [ ] | Standing [ ] | Unstable Walls [ ] |
| Caved [ ] | Concealed [ ] | Eroded [ ] | Intact [ ] | Subsided [ ] | Wind Erosion [ ] |
| Caved, Partial [ ] | Concealed, Partial [ ] | Eroded, Partial [ ] | Open to Entry [X] | Unconfined [ ] | |
| Collapsed [ ] | Confined [ ] | Fenced [ ] | Rotten Cribbing [ ] | Other: Wall Slough | |

12) SIZE OF FEATURE Indicate size of feature and specify units (feet or meters).

Measurement: Actual [X] Estimate [ ] Feet [X] Meters [ ]

Length: NA x Width: 4 x Depth or Height: 7

Slope (Degrees): N/A Bank Stability: Stable [X] Unstable [ ] Marginally Stable [ ]

13) WATER Is water present at the feature? Circle one. YES NO

Is water emanating from or passing through the feature? Circle one. YES NO

a) If water is present, how does it occur? Check all that apply.

Standing [ ] Filled [ ] Partly Filled [ ] Flowing [ ] Intermittent [ ]

b) If present, determine: GPM: 9.35 Conductivity: 300 pH: 6.5

c) Observe water bed color. (Check all that apply, or specify other.)

Brown [ ] Green [ ] Yellow [ ] Yellow-orange [X] Orange [ ] Gray-black [ ] Other (specify) [ ]

14) PLANTS Are plants present on or around the feature? Circle one. YES NO

If yes, check one.

Healthy [ ] Stressed [ ] Dead [ ] Barren [ ] Partial Revegetation [X] Full Revegetation [ ] Other (specify) [ ]

15) STAINING Stains may indicate spills, oxidation, or alteration. Are non-water-related stains present? YES NO

If stains are present, check appropriate color or specify other. Yellow-orange [X] Gray-black [X] Other (specify) [ ]

16) MACHINERY Is machinery present at this feature? Circle one. YES NO

a) Location of machinery. Check all that apply.

Inside Building [ ] No Building [ ] Outside Building [ ] Other (specify) [ ]

b) Type of machinery. Check all that apply or specify other.

| | | | | |
|---|---|---|---|---|
| Amalgamation Equipment [ ] | Crusher(s) [ ] | Ore Bin(s) [ ] | Stamp Mill(s) [ ] | Vat(s) [ ] |
| Arrastre [ ] | Flotation Cell Group [ ] | Retort(s) [ ] | Tank(s) [ ] | |
| Ball Mill(s) [ ] | Leach Tank(s) [ ] | Rod Mill(s) [ ] | Thickener(s) [ ] | |

Others (specify) [ ]

17) PHOTOGRAPH NUMBERS NONE

18) SKETCH NUMBERS NONE

COMMENTS
Water bed color represents bed color at portal.

**Example 6.**–Example of completed questions 10 through 18 and Comments section.

## Question 13

Question 13 (see Example 6) is **WATER**. Presence of water is a significant item to note, and the condition of the water may indicate acid water drainage. The location of the observation is also important. Acidic water leaving an opening may be clear and not produce or precipitate yellowish ferrous anyhdrite or other substances for some distance from the opening. Therefore, include the location of the observation in the comments section and on the sketch map. This question is composed of three parts and three observations. First: "Is water present at the feature?" Circle **Yes** or **No**. If yes, continue, otherwise go to part "c." The second part is, "Is water emanating from or passing through the feature?" Circle **Yes** or **No**.

Assuming water is present, the investigator is asked to make three observations. The third observation applies to areas with water or that may have water at some time of the year.

Part "a" is: "If water is present, how does it occur? Check all that apply." Five choices are listed: standing, filled, partly filled, flowing, and intermittent. Choose all that apply and place a check or an "X" in the box beside the choice.

Part "b" asks for three measurements. "If present, determine gpm (gallons per minute); conductivity, and pH." Gpm is the flow rate in gallons per minute; conductivity is the ability to pass electricity; and pH refers to acidity or basicity. These measurements are good indicators of possible environmental hazards, including acid water. For each, place the value in the appropriate box.

### Flow Rate

To determine water flow rate, find a relatively straight section in the water channel, preferably 0.9 m (3 ft) long, and determine the average width and depth. Use a small piece of twig or similar item to determine the flow rate (time to travel 3 ft, for example and determine the time (in seconds) for the object (twig) to travel the given distance (e.g., 3 ft). Calculate gallons per minute as follows:

$$\frac{60 \text{ sec/min} \times \text{length (in inches)} \times \text{average width (in inches)} \times \text{average depth (in inches)}}{(231 \text{ in}^3/\text{gal}) \times \text{time (in sec)}}$$

or

$$(0.26) \times \frac{\text{length} \times \text{width} \times \text{depth}}{\text{time}} = \text{gpm}$$

where:

Length, width, depth in inches; time in seconds.

### Conductivity

Conductivity is the measurement of the amount of electricity that will pass through something. In this text, conductivity is applied to water. Generally speaking, as the amount of total dissolved solids (TDS) increases in water, the water conductivity increases. The TDS can be a function of a variety of factors and may or may not by itself indicate a problem. TDS can be measured either as weight of solids per unit volume (milligrams per liter [mg/L]), or as a function of electrical conductivity (microsiemens [um]). Natural "fresh" water, uncontaminated by metals, can have a TDS from near zero up to 1,000 mg/L. Brackish water may have TDS as high as 10,000 mg/L. Contaminated mine drainage waters can contain

from several hundred to several thousand milligrams per liter TDS. To collect the data, insert the instrument sensor into the water and record the reading. Carefully follow the manufacturer's instructions.

pH measurements

In this text, the term "pH" refers to the acidity (negative log of the hydrogen ion concentration) of water and ranges from 0 to 10 (although the pH scale ranges from 0 to 14), with 0 being very acidic, 14 very basic, and 7 neutral. Most natural surface water has a pH between 6.5 and 8.5. Natural ground water pH usually ranges between 6.0 and 8.5. Measurement of the water's pH, using either a probe and meter or proper litmus paper, will indicate whether the water presently is acidic. Water with a pH of less than 5.5 is of concern.

pH probes with direct digital readout are readily available, inexpensive, and relatively easy to use. Some need calibration with a standard solution before each use while others do not. In either case, dip the probe into the water and record the reading. Litmus paper dipped in the water will display a color related to the pH; this color is compared to a chart and an estimate of the pH is read. Litmus papers can be obtained in several pH ranges (e.g., 4-11, 6-8, 6.5-7.5). A variety is often needed.

The choice of pH measuring devices depends on several factors, including operator knowledge, time, and economics. If a pH meter is used, carefully follow the manufacturer's directions.

Part "c" asks: "Observe water bed color." There are two media which may have color and the two should not be confused. Water which is cloudy (carrying suspended particles) will have a certain color. However, if the water is clear, the color of the material over which the water flows will be observable. This latter material is the water bed. The color of this material can assist in determining if the water poses an environmental hazard. The bed color may be the "natural" color of the rock indicating no apparent precipitation, or the color of precipitates which have coated the water bed material. If the water is cloudy, note both the presence of cloudiness and the color in the comments box at the end of the form. In dry climates, water may not be present, but stains may still occur on dry water beds. Look for water courses and stains in both wet and dry climates.

Look at the water bed color and choose one of the listed six colors. If the observed color is not listed, fill in the box labeled "Other."

In the Grizzly Bear Mine example (see Example 6), water is present at the site so the first question in the water section is answered Yes. Water is flowing from the adit, so the second question "Is water emanating from or passing through the feature?" is also answered Yes. Part "a" is marked "Flowing" because water is flowing from the adit.

Three measurements are collected, gpm, conductivity, and pH. The water from the adit flows in a channel about 6 in. average width, and about 2 in. average depth. A piece of twig placed in the water traveled 3 ft in 12 sec. Using the above formula, a volume of 9.35 gpm was calculated.

Both pH and conductivity readings are collected (pH = 6.5 and conductivity = 300) and entered into the appropriate boxes. The water bed color is observed to be yellow-orange, so an "X" is placed in the box beside the color yellow-orange. The water bed color was noted as the water left the portal. This information is entered in the "Comments" section. This completes question 4.

## Question 14

Question 14 (see Example 6) is **PLANTS**. Specifically, "Are plants present on or around the feature?" Answer by circling either **Yes** or **No**. If yes, continue and place an "X" or check in the appropriate box provided or fill in "Other." The answer has two parts, the health of the plants, and the relative abundance. If plants appear healthy but are fewer in number than on surrounding soil, mark "Healthy" and "Partial Revegetation."

Plants may show stress by being more yellow than similar plants in surrounding areas, or may be droopy, or pale in color. Stress may be produced by lack of water, poor soil, compact soil, or toxic materials. If possible, also note if plants appear to be a similar or different type compared to those areas generally surrounding the site. Note this information in the "Comments" section. Do not confuse plant death from stress with plant death due to natural seasonal changes.

Some plants are more tolerant of metals than other plants. Geo-botanical prospecting uses this phenomena in the search for metallic deposits by looking for those specific plants which "thrive" on high metals soils relative to other plants. These plants (depending on which part of the United States the inventory is taking place) should be noted and utilized as a possible indicator of heavy metals.

In the Grizzly Bear Mine example, a few healthy green plants are growing next to the portal of the adit, near the water. In example 6, the answer **Yes** is circled, and an 'X' is placed in the box next to "Healthy." Because only a few were present, "Partial Revegetation" was marked.

## Question 15

Question 15 (see Example 6) deals with **STAINS**. Specifically, "Stains may indicate spills, oxidation, or alteration. Do stains occur on rocks, foundations, or other non-water-related features?" Circle **Yes** or **No**. If yes, check the appropriate color or specify the color if not listed.

Question 15 addresses several concerns. If sulfides are present in the rock they may oxidize and form a yellow-orange stain. This could be an indicator of possible acid generation. Gray-black (possibly brown) stains are most commonly associated with petroleum products used in gas- or diesel-powered equipment. If these products are spilled, they often leave a stain. Some chemical stains also may be yellowish to yellow-orange in color.

In the Grizzly Bear Mine example, a faint orange stain on some of the rock next to the entrance to the adit is observed. On the ground nearby is an odd gray-black stain. From the pre-field work it was determined that the mine operated after 1920, so gasoline or diesel power may have been used. Both stain colors should be noted. As shown in Example 6, **Yes** is circled and an "X" is placed in the box beside both "Yellow-orange" and "Gray-black."

## Question 16

Question 16 (see Example 6) is **MACHINERY**. Specifically, "Is machinery present at this feature?" Answer by circling **Yes** or **No**. If yes, continue to part "a," location of machinery, and part "b," type of machinery. For example, if the feature is a mill with the remains of mill equipment, question No. 1, "feature" would be marked "mill building," and question 16 would be marked "yes" machinery is present. Parts "a" and "b" would then be completed.

For part "a," determine the location of the machinery and check all that apply. The choices are inside a building, outside a building, no building, and other. Check, or place an "X" in the appropriate box or fill in "Other."

In part "b," place a check or an "X" in the appropriate box beside the general type of machinery present. Check all that apply. If the device is not listed, fill in the blank box labeled "Other."

The Grizzly Bear Mine has some remains of machinery near an old mill building but no machinery of any type visible at the portal. The answer **No** is circled because the feature under examination is an adit with no visible machinery.

Questions 17 and 18

Question 17 is **PHOTOGRAPH NUMBERS**; question 18 is **SKETCH NUMBERS**. These questions are to be answered in the same general way as questions 8 and 9, respectively.

Comments

Use the Comments section to add specific notes.

Part III–Supplementary Data

Part III of the AML Inventory form is a gridded sheet to be used for a sketch map of a site, section of a site, or local feature. At the top of the page are four boxes labeled "Site Number, Sketch Number, Page _ of _, and Date." Fill in each box appropriately if a sketch map is drawn. On the map, place a text scale (1 cm or 1 in. represents a given distance, meter or feet, on the ground), a bar scale, and a north arrow showing the direction to north.

### Task 5–Review Form for Completeness

Review the entire form for completeness. Review all notes, pictures, and data to be sure you have everything necessary to adequately describe the feature. This feature is now complete and you are ready to proceed to the next feature.

### Task 6–Review All Sets of Data for Completeness

Before leaving the area, review all sets of site data for completeness; has any information been overlooked? If so, collect these data.

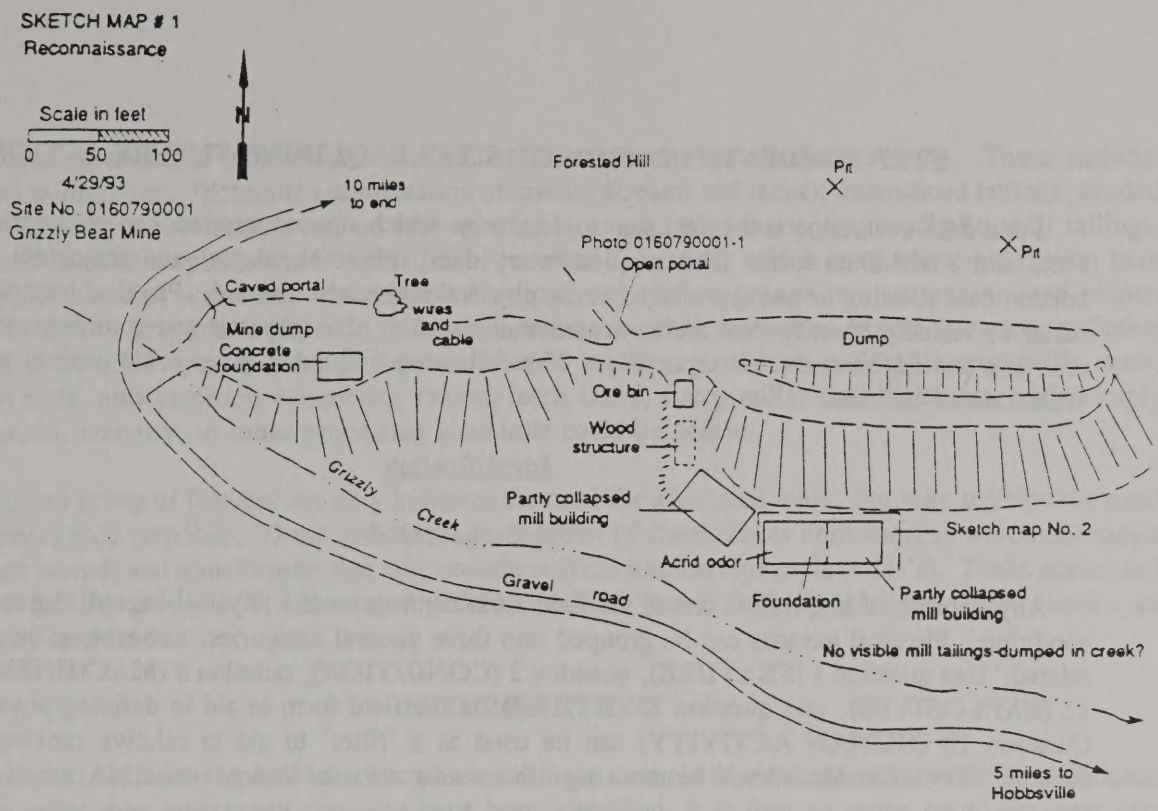



**Figure 18.--Example of a site sketch map which shows general area and location of dumps, buildings, and other significant features.**

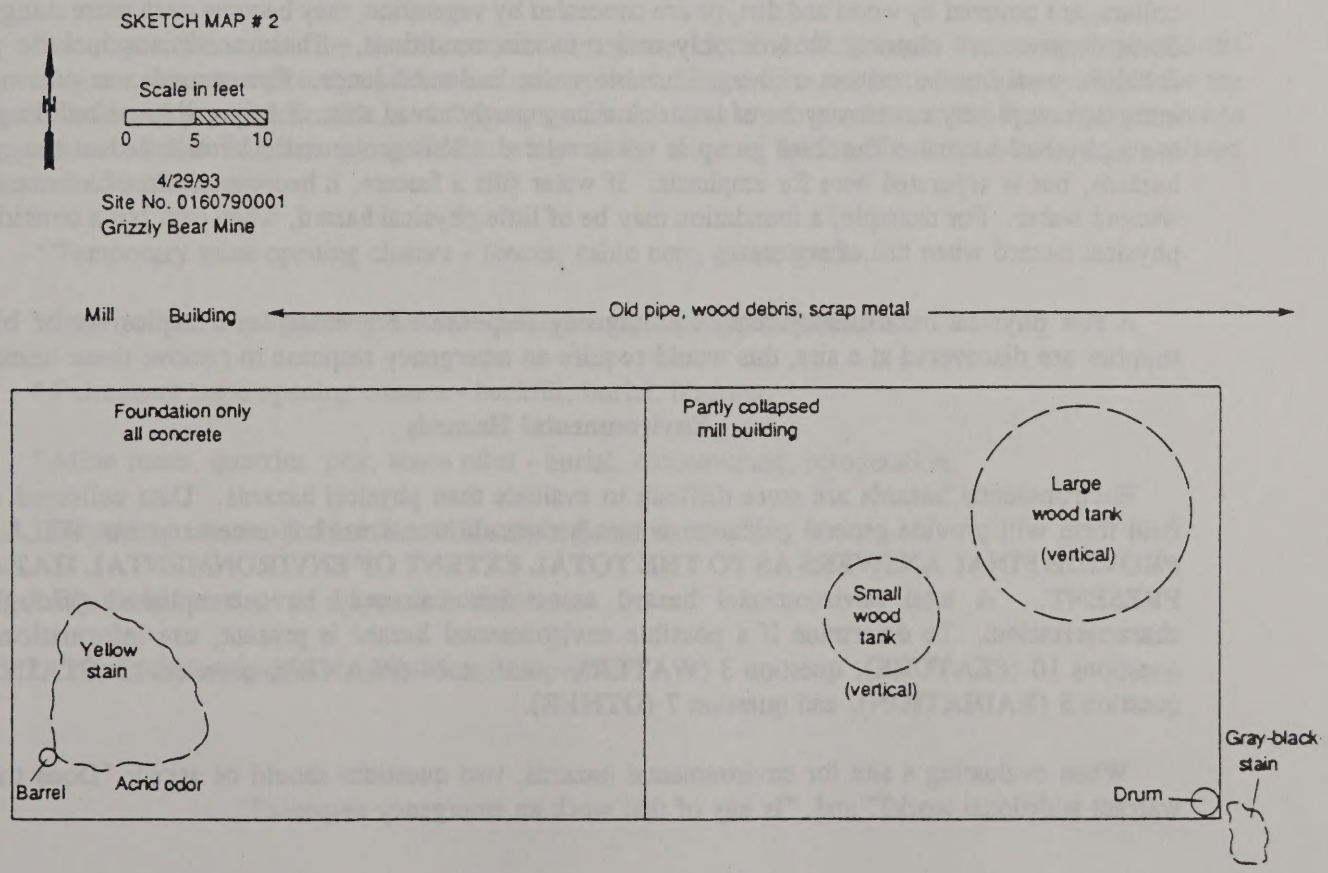



**Figure 19.--Example of a large-scale sketch map showing a selected portion of a site.**

## STEP IV–IDENTIFICATION OF SITES REQUIRING FUTURE ACTION

Field data evaluation is the next step to determine which sites warrant additional attention. The Pre-Field and Field Data forms (and supplementary data), photo(s), map(s) and sketch(es) for each site contain data relating to two types of hazards, physical and environmental. Physical hazards usually are easier to visually identify than are environmental hazards. The physical and environmental hazards at each site should be evaluated separately. The following discussion gives some general guidelines for evaluation of the data.

### Identification

#### Physical Hazards

Any item listed in question one of the field form can represent a physical hazard, depending upon its condition. Physical hazards can be grouped into three general categories: airborne, ground, and water related. Use question 1 (**FEATURE**), question 2 (**CONDITION**), question 8 (**MACHINERY**), question 11 (**EXPLOSIVES**), and question 12 (**OTHER**) on the field form to aid in defining physical hazards. Question 10 (**HUMAN ACTIVITY**) can be used as a 'filter' to aid in relative ranking of physical hazards. The same hazard will be more significant near areas of heavy human use or activity.

Airborne hazards are those that could affect air travel and include wires, cables, power lines, and tram lines. These are especially dangerous to helicopters. Ground hazards represent the largest group. This group can include adits, cisterns, tunnels, quarries, declines, sumps, shafts, buildings, glory holes, machinery, and highwalls. Some, such as shafts, are by their very nature, dangerous. If they have soft collars, are covered by wood and dirt, or are concealed by vegetation, they become even more dangerous. Some features are physical hazards only under certain conditions. These conditions include partial collapse, partly caved, rotten cribbing, unstable walls, and subsidence. For example, an adit open to entry or completely caved may be of less risk than a partly caved adit. Partly collapsed buildings also are a physical hazard. The third group is water related. This group could be included in the ground hazards, but is separated here for emphasis. If water fills a feature, it becomes more of a hazard than without water. For example, a foundation may be of little physical hazard, when dry, but a considerable physical hazard when full of water.

A few physical hazards may require emergency response. For example, if explosives or blasting supplies are discovered at a site, this would require an emergency response to remove these items.

#### Environmental Hazards

Environmental hazards are more difficult to evaluate than physical hazards. Data collected on the field form will provide general guidance as to whether additional work is necessary, but **WILL NOT PROVIDE FINAL ANSWERS AS TO THE TOTAL EXTENT OF ENVIRONMENTAL HAZARDS PRESENT**. A total environmental hazard assessment can only be accomplished through site characterization. To determine if a possible environmental hazard is present, use information from questions 10 (**FEATURE**), question 3 (**WATER**), question 14 (**PLANTS**), question 15 (**STAINING**), question 5 (**RADIATION**), and question 7 (**OTHER**).

When evaluating a site for environmental hazards, two questions should be asked: "Does this site warrant additional work?" and, "Is any of that work an emergency response?"

Certain observations indicate the need for additional work (site characterization). These include: breached tailings dams (potential sedimentation of creeks, streams and lakes); unconfined tailings; eroded tailings; flowing water from, over, or near an adit, large pit, mine dump, ore stockpile, mill tailings, leach pad, or solution pond; water with a pH of less than 5.5; water with a conductivity of greater than 1,000 microsiemens; water bed with colors of yellow, red, yellow-orange, or orange; stressed plants; yellow-orange or gray-black stains on rocks, foundations or other non-water-related features; radiation readings above 500 cps; and the presence of certain machinery such as ball mills, rod mills, vats, flotation cells, amalgamation equipment, retorts, leach tanks, stamp mills, and thickeners, which imply that cyanide, mercury, or other processing chemicals could be present.

A second group of features not only indicates the need for additional work, but may indicate the need for an emergency response. These include: bags or drums of chemicals or containers in which chemicals have been stored, and transformers that may contain polychlorinated biphenyls (PCB's). Tanks associated with the milling process (if full or partly full), or leach ponds with liquids, also may require an emergency response.

## FUTURE ACTIONS

When the AML inventory/evaluation phase has been completed, and sites that warrant additional attention other than emergency response have been identified, it is time to move on to the next two phases: site characterization and remediation. These phases result in the elimination of public safety and environmental hazards and usually are handled by specialists. An overview is presented in this section.

### Elimination of Public Safety Hazards

For physical hazards, the site characterization phase of the AML process is unnecessary, and the investigator can move directly to the remediation phase. There are a number of options available for the remediation of physical hazards, and they range from temporary to permanent and from inexpensive to expensive. A detailed discussion of each is beyond the scope of this handbook; however, a generalized list would include:

° Temporary mine opening closure - fences, cable nets, gates, grates.

° Intermediate mine opening closure - concrete caps, plugs, bulkheads.

° Permanent mine opening closure - backfill, burial, blasting.

° Mine roads, quarries, pits, waste piles - burial, recontouring, revegetation.

° Structures - controlled burns, stabilization, demolition.

° Equipment - removal, disposal, burial.

° Chemicals, explosives - destruction, removal.

## Elimination of Environmental Hazards

### Site Characterization

Site characterization is conducted at those sites selected in Step IV above as having or potentially having serious environmental problems. Site characterization involves detailed examination of a site to accurately define the nature and extent of contamination and the risks to the environment and human health.

Mining and minerals-related sites can be very complex physically and chemically due to the broad spectrum of ore types, processing techniques, mining methods, and metal recoveries that were emphasized during the life of an operation. Traditional site characterization methods are often ineffective for large-volume mining wastes containing generally low, but highly variable, metal contents. This is especially true in mining districts which have high levels of naturally occurring metals. Hence, the quantities and areal distribution of contaminated material, the exact nature of contamination, and the risks posed by the contamination are frequently inadequately defined. This could lead to costly and ineffective remedial decisions and actions. Effective characterization of mining sites clearly needs specialized methods tailored to these unique problems.

In response, the USBM established the Mine Site Characterization Program. USBM experience indicates that the basic problem—what is there and how much is there—is fundamentally similar to the process of mineral discovery and lends itself to adaptations of techniques used by the USBM and industry for mineral exploration and resource evaluation. Accordingly, the Program is producing mine-site-specific characterization procedures, risk assessment protocols, and cost estimating systems. Developed methods and technical assistance are available upon request to government agencies dealing with AML problems.

In general, site characterization studies usually are organized by environmental media and major concerns, such as illustrated in the example matrix below. Specific studies rely on geophysical, geochemical, biological, mineralogical, geohydrological, and geostatistical approaches and techniques.

Recommended Studies

| Concerns | Waste Piles | Soil | Water | Vegetation | Wildlife |
|---|---|---|---|---|---|
| Acid drainage . . . . . | X | X | X | | |
| Stressed/absent vegetation . . . . . | X | X | X | X | |
| Erosion/sedimentation . . . . . | X | | X | | |
| Threatened/endangered species . . | | | X | X | X |
| Frequent human presence . . . . . | X | X | X | | |
| Chemicals. . . . . | X | X | X | | |

### Remediation

After site characterization has fully defined the problem, options for correcting the problem and remediation alternatives need to be evaluated. This phase requires considerable flexibility and objectivity to ensure that all significant concerns are addressed, that the unique aspects of individual sites are recognized, and that cost/benefit ratios are adequately considered.

As stated earlier, mining and mineral-related sites can be very complex physically and chemically. Thus traditional approaches to remediation may not be completely effective, or, as is the case with removal or vitrification of large waste piles, may be prohibitively expensive.

In response, the USBM established the Environmental Technology Research Program to address the remediation solutions required specifically for mining sites. Efforts are centered on development of technology that supports reprocessing of past wastes, decontamination of leach piles, treatment of acid mine drainage, detoxification of metallurgical wastes, and mitigation of damage caused by mine subsidence. The results of these efforts are available upon request.

In general, remediation can involve one or more of the following:

- Containment - caps, revegetation, dams, grouting, backfilling.
- Water treatment - reagents, wetlands, diversion, biochemical methods.
- Material treatment - reagent injection, reprocessing.

The primary deciding factors usually are cost, effectiveness, and time frame for remedy. Also, as was the case with site characterization, the choice of methodologies must be done in reference to the ambient (natural background) levels in the environment.

## CONCLUSIONS

By the time an investigator has reached this part of the handbook, he or she has seen how to conduct an AML inventory and evaluation by (1) developing an initial list of AML sites, (2) selecting sites for field investigation, (3) conducting site investigations, (4) identifying sites that require future actions. The user also has obtained an overview of site characterization and remediation. The investigator is now in a position to make, or assist with, planning and implementation decisions on AML hazard identification and mitigation.

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## APPENDIX A.–MINING AND MINERAL PROCESSING TERMS

The following definitions are provided to assist the reader who may not be familiar with some of the mining terms used in this handbook. Most of the definitions are paraphrased from the Bureau's Special Publication, "A Dictionary of Mining, Mineral, and Related Terms," compiled and edited by P. W. Thrush, 1968.

**abandoned mine; abandoned workings**–Excavations, either open, caved, or sealed, that are deserted and in which further mining is not intended.

**acid mine water, acid mine drainage (AMD)**–Mine water which contains sulfuric acid, mainly due to the oxidation of iron pyrite.

**activator (flotation mill)**–A reagent that facilitates flotation of selected mineral species in a flotation cell. See "depressant."

**adit**–A horizontal or nearly horizontal passage driven in rock from the surface for the working or dewatering of a mine.

**amalgamation**–The process by which mercury is alloyed with some other metal to produce an amalgam. Used at one time for the extraction of gold and silver from pulverized ores.

**ANFO**–Blasting agents comprised of a mixture of ammonium nitrate and fuel oil.

**arrastre; arrastra**–A circular rock-lined pit in which broken ore is pulverized by stones attached to a pillar and dragged around the pit. The arrastre was in common use in the western and southwest United States in the 18th and 19th centuries.

**arsenopyrite**–Iron-arsenic sulfide, FeAsS.

**assay**–(1) (verb) to determine the amount of metal contained in an ore; (2) (noun) the result of making such a determination. Note: difference between assay and analysis: in an analysis all of the chemical constituents are determined; in an assay only certain constituents are determined, usually those of commercial interest.

**ball mill**–A rotating horizontal cylinder in which nonmetallic materials are ground using various types of grinding media such as quartz pebbles, porcelain balls, or steel balls.

**barren solution**–Leaching solution that has been chemically stripped of metal values. Typically, the barren solution is recharged with leaching agent and recycled.

**beneficiation**–The processing of ores for the purpose of (1) regulating the size of a desired product, (2) removing unwanted constituents, and (3) improving the quality, purity, or assay grade of a desired product.

**blasting cap**–An enclosed metal shell containing a charge of detonating compound which is ignited by electric current or the spark of a fuse. Used for detonating high-yield explosives.

**blasting gelatin**—A high-yield explosive consisting of nitroglycerin and nitro-cotton. It is a strong explosive and is a rubber-like, elastic substance that is unaffected by water.

**blasting machine**—A portable device that generates enough electric current to detonate electric blasting caps.

**bore hole**—An exploratory or prospecting hole made by drilling.

**carbon column**—A columnar tank containing activated charcoal in which metal values are adsorbed by the charcoal from a pregnant leach solution circulated within.

**carbon-in-leach (CIL)**—A recovery process in which a slurry of gold ore, free carbon particles, and cyanide are mixed together. Cyanide dissolves gold from the ore and the gold is simultaneously adsorbed onto the carbon. The carbon is separated from the slurry and the gold recovered.

**carbon-in-pulp (CIP)**—A process to recover dissolved gold from a cyanide leach slurry. Coarse activated carbon particles are moved countercurrent to the slurry absorbing gold as it passes through the circuit.

**carbon stripping**—Process wherein metal-laden charcoal from the carbon columns is stripped of metal values with a hot caustic solution. The stripping solution is then passed to electrowinning cells where the metals are electroplated on steel wool cathodes.

**carbonate rocks**—Rocks composed primarily of the mineral calcite, $CaCO_3$.

**chalcopyrite**—Copper-iron sulfide, $CuFeS_2$.

**Chilean mill; edge runner**—A mill having vertical rollers running in a circular enclosure with a stone or iron base or die. There are two classes: (1) those in which the rollers gyrate around a central axis, rolling upon the die as they go (the true Chilean mill), and (2) those in which the enclosure or pan revolves, and the rollers, placed on a fixed axis, are in turn revolved by the pan.

**cistern**—A settling tank for liquid slag, slurry, or pulp.

**claim**—An area of land claimed by an individual or corporation for the ultimate purpose of mineral extraction. The dimensions of a lode claim are 183 m by 457 m (600 by 1,500 ft); for a placer claim, 183 m by 402 m (600 by 1,320 ft).

**cleaner cell, recleaner cell**—Secondary cells in a flotation mill for the retreatment (flotation) of concentrate from the primary (rougher) cells.

**collar**—The term applied to the timbering or concrete around the mouth or top of a shaft. The junction of a mine shaft and the surface.

**collector (flotation mill)**—A reagent that aids or facilitates the attraction of mineral particles to the froth in a flotation cell. Xanthate is a common collector in use from the 1930s to date.

**comminution**—The reduction of solids to minute particles by crushing and grinding to liberate metal values.

**commodity**—Mineral product produced at mine or mill (e.g., gold, silver, copper).

**concentrate; mineral concentrate**—(noun) Enriched ore after the removal of waste in a beneficiation mill. Usually referred to in the plural form, "concentrates."

**concentrate**—(verb) To separate metal or ore from the associated gangue or barren rock.

**concentrator**—Mill or plant in which ore is concentrated by removing unwanted constituents.

**conditioner (flotation mill)**—Substances added to the pulp in a flotation mill to maintain the proper pH to "protect" certain salts such as NaCN that would decompose in an acid circuit. Sodium carbonate (Na2CO3) and calcium oxide (lime—CaO) are the most common conditioning agents since most flotation pulps should be alkaline.

**country rock**—General term applied to the rock surrounding and penetrated by mineral veins; in a wider sense applied to the rocks invaded by and surrounding an igneous intrusion.

**crosscut**—(1) A passageway driven at right angles to the main entry to connect it with a parallel entry or air course. (2) A horizontal opening driven across the course of a vein or in general across the direction of the main workings.

**crusher**—A machine for crushing rock or other materials. Among the various types of crushers are the ball mill, gyratory crusher, Hadsel mill, hammer mill, jaw crusher, rod mill, rolls, stamp mill, and tube mill.

**cyanide**—A salt or ester of hydrocyanic acid. In aqueous solution, cyanide is used to dissolve metal values from gangue material for later recovery.

**cyanidation**—Recovery process involving the use of cyanide compounds to dissolve metal values.

**cyclone; cyclone classifier**—A device for classification by centrifugal means of fine particles suspended in water whereby the coarser grains collect and are discharged at the apex of the vessel, while the finer particles are eliminated with the bulk of the water at the discharge orifice.

**decline**—An access to an underground mine which descends at an appropriate angle, often in a spiral fashion (spiral decline).

**deposit**—See "mineral deposit."

**depressant (flotation mill)**—A reagent that causes selected mineral species to sink in a flotation cell. See "activator."

**detonating fuse**—A fuse consisting of a high-yield explosive that fires the charge without the assistance of any other detonator. It consists of a core of pentaerythritol tetranitrate (P.E.T.N.) enclosed in tape and wrapped with textile countering yarns. Usually the fuse is reinforced or completely enclosed in a strong waterproof plastic outer cover. The finished external diameter is normally about 5 mm (0.2 in). "Primacord" is the best known brand name. Also known as detonating cord.

**detonator**–A device for producing detonation in a high-explosive charge initiated by a safety fuse or by electricity.

**developed prospect**–Prospect wherein infrastructure is in place and mine development has been completed but property has not produced ore.

**dolomite**–A rock-forming carbonate mineral, $CaMg(CO_3)_2$.

**dore'**–Gold and silver bullion which remains in a cupelling furnace after lead has been oxidized and skimmed off.

**dredge**–A raft or barge on which is mounted machinery for the excavation and washing of alluvial deposits or gravel for gold, tin, platinum, diamonds, etc.

**drift**–A horizontal passage underground. A drift follows the vein, as distinguished from a crosscut, which intersects it, or a level or gallery, which may do either.

**drill steel**–A round or hexagonal steel rod for boring in coal, ore, or rock.

**dump**–A pile or heap of waste rock material or other non-ore refuse near a mine.

**dynamite**–An industrial explosive which is detonated by blasting caps. The principal explosive ingredient is nitroglycerin or specially sensitized ammonium nitrate.

**electrowinning**–Recovery of a metal from an ore or solution by electrochemical processes.

**explored prospect**–Prospect on which resources have been defined.

**face**–The surface exposed by excavation. The working face, front, or forehead is the face at the end of the tunnel heading, or at the end of the full size excavation.

**flotation**–The method of mineral separation in which a froth created in water by a variety of reagents floats some finely crushed minerals whereas other minerals sink.

**flotation cell**–Device in which froth flotation of ores is performed.

**fuse**–A core of black powder wrapped with hemp or cotton threads or tape, with various waterproofing compounds between each.

**frother**–A reagent which serves to stabilize the froth in a flotation cell until it can be scraped off into the concentrate launder.

**galena**–Lead sulfide, PbS.

**glory hole**–A funnel-shaped excavation, the bottom of which is connected to a raise driven from an underground haulage level.

**GPS receiver**–A hand-held radio receiver which receives latitude/longitude coordinates from an earth-orbiting satellite.

**gravity mill**–A process in which heavy metals or minerals are separated from waste by the action of agitation and gravity on materials suspended in a liquid, usually water.

**grizzly**–A device for the coarse screening of bulk materials. A rugged screen for rough sizing at a comparatively large size (for example, 150 mm or about 6 in).

**hand auger**–A tool modeled after the carpenter's drill used in soil sampling.

**HCl**–Hydrochloric acid.

**headframe**–The vertical steel or timber frame at the top of a shaft which carries the sheave or pulley for the hoist.

**heap leach**–A recovery process in which prepared ore is stacked in heaps on impervious pads and a solvent percolated through the heap to dissolve selected metal values.

**heavy metal**–Principally the metals zinc, copper, cobalt, and lead. Sometimes the term is used to include one or more of the following metals: bismuth, cadmium, gold, indium, iron, manganese, mercury, nickel, palladium, platinum, silver, thallium, and tin.

**Hg**–Mercury.

**highwall**–The unexcavated face of exposed overburden and coal or ore in an opencast mine or the face or bank on the uphill side of a contour strip mine excavation.

**hoist**–(1) A drum on which wire rope is wound in the engine house as the cage or skip is raised in the hoisting shaft. (2) An engine with a drum used for winding up a load from a shaft.

**$H_2SO_4$**–Sulfuric acid.

**impoundment**–An area, often contained by a dam, used as a water supply for a mining or milling operation or as settling ponds for tailings slurries.

**inclined shaft or incline**–A nonvertical shaft; usually along the dip of a vein.

**industrial mineral**–A mineral valued for its physical or chemical properties rather than its metal content (e.g., garnet, kyanite, borate minerals, clay, etc.).

**infrastructure**–Ancillary facilities such as power, water, and sanitation systems, access and haul roads, shops, offices, warehouses, etc., at a mine site.

**initiation**–The process of causing a high explosive to detonate.

**iron oxide**–iron (and possibly other metallic ions) in combination with oxygen.

**jaw crusher**–A primary crusher designed to reduce large rocks or ores to sizes capable of being handled by any of the secondary crushers. It consists of a moving jaw, hinged at one end, which swings toward and away from a stationary jaw in a regular oscillatory cycle.

**jig; mineral jig**–A machine in which the feed is stratified in water by means of a pulsating motion and from which the stratified products are separately removed, the pulsating motion usually being obtained by alternate upward and downward currents of the water.

**jig plant**–A recovery plant that uses mineral jigs to recover mineral values.

**latitude**–Locational coordinate expressed in degrees, minutes, and seconds north or south of the equator.

**leach pad**–A specially prepared area covered by an impervious liner on which ore is placed for leaching.

**leaching**–(1) The removal in solution of the more soluble minerals by percolating waters. (2) Extracting a soluble metallic compound from an ore by selectively dissolving it in a suitable solvent, such as water, sulfuric acid, hydrochloric acid, cyanide, etc.

**level**–A main underground roadway or passage driven along the level course to afford access to the stopes or workings and to provide ventilation and haulageways for the removal of ore.

**limestone**–A rock composed primarily of the mineral calcite, $CaCO_3$.

**limonite**–Iron hydroxide, $HFeO_2$.

**long tom**–A long trough or sluice for washing gold-bearing sand and gravel.

**longitude**–Locational coordinate expressed in degrees, minutes, and seconds east or west of the Greenwich meridian.

**marble**–A metamorphic carbonate rock, generally derived from limestone.

**marcasite**–Iron sulfide, $FeS_2$.

**Merrill-Crowe plant**–A method of recovering metal values from solution by precipitation with zinc dust.

**mercury fulminate; mercuric fulminate; mercuric cyanate; fulminate of mercury**–A mercury compound used in the manufacture of blasting caps and detonators for detonating explosives.

**mesh**–The number of openings per unit area of a screen (sieve).

**methane**–A tasteless, colorless, nonpoisonous, explosive, and odorless gas, formed by the decomposition of organic matter. Methane is the most common explosive gas found in coal mines.

**mill**–A mineral treatment plant in which crushing, grinding, and further processing of ore is conducted to produce a product.

**milling**–The processing of ore to produce a product.

**mine**–An excavation for the extraction of ore or other economic minerals.

**mine development**–The term used to describe the operations involved in preparing a mine for ore extraction. These operations may include tunneling, sinking, crosscutting, drifting, and raising.

**mineral**–An inorganic substance occurring in nature, though not necessarily of inorganic origin, which has (1) a definite chemical composition or, more commonly, a characteristic range of chemical composition, and (2) distinctive physical properties or molecular structure.

**mineral dressing**–Physical and chemical concentration of raw ore into a product from which a metal can be recovered at a profit. Mineral dressing processes are also applied to industrial wastes to retrieve useful byproducts.

**mineral deposit**–A surface or underground body of mineral matter that may be utilized for its industrial mineral or metal content.

**mineral location**–A location where the occurrence of mineralized materials has been noted.

**mining district**–An area or region characterized by the occurrence of specific mineral suites or the nature of mineral deposits.

$NaHCO_3$–Sodium bicarbonate.

NaCN–Sodium cyanide.

**non-energy leasable commodity**–Leasable commodities such as phosphate, salt, sulfur, etc. that are not sources of energy (such as coal, uranium, etc.).

**open-pit mining; opencut mining**–A form of operation designed to extract minerals that lie near the surface. The mining of metalliferous ores by surface-mining methods is commonly designated as "open-pit mining" as distinguished from "strip mining" of coal and the "quarrying" of other nonmetallic materials such as limestone, building stone, etc.

**ore**–A mineral, or mineral aggregate, containing precious or useful metals or metalloids, and which occurs in such quantity, grade, and chemical combination as to make extraction commercially profitable.

**ore bin**–A receptacle for ore awaiting treatment or shipment.

**ore body**–Generally, a solid and fairly continuous mass of ore which may include low-grade ore and waste as well as high-grade material.

**ore chute**–An inclined passage, from 0.9 to 1.2 m (3 to 4 ft) on a side, for the transfer of ore to a lower level in underground workings.

**ore deposit**–A general term applied to rocks containing minerals of economic value in such amount that they can be profitably exploited. Also applied to deposits which, though they may not be immediately capable of profitable exploitation, may yet become so by change in the economic circumstances that control their value.

**past producer**–Mining property that has produced ore in the past.

**pH**–A measure of the degree of acidity or basicity of a solution. At 25° C, a pH of 7 is neutral. Acidity increases with values below 7, and basicity increases with values above 7.

**pine oil**–A commercial distillate of wood widely used as a frothing agent in flotation processes.

**pit**–Surface excavation of relatively large dimensions from which ore and waste has been extracted.

**pit, exploration**–Small (usually less than 5 m deep) pit excavated to explore for minerals.

**placer**–A mineral concentration resulting from weathering processes usually involving running water. Placer deposits are typically composed of heavy minerals, with gold, platinum, tin, and diamonds being the most important.

**Public Land Survey (PLS) system**–Locational system whereby areas of land are divided into 36-square mile increments north or south of a base line and east or west of the principal meridian established for the general region. Pamphlets, booklets, and other published information that describe the PLS system and how to use the system are available at most USGS Map Sales offices.

**portal**–(1) The surface entrance to a drift, tunnel, or adit. (2) The entrance to a mine.

**powder**–A general term for explosives, including dynamite, but excluding caps.

**pregnant solution**–Metal-laden solution (cyanide, acid, etc.) resulting from a leach process.

**prill**–Spherical particle about the size of a buckshot. Used in describing the shape of ANFO pellets.

**primacord**–A fuse composed of an explosive core within a textile or plastic covering. Used to detonate the explosives that are in direct contact with it.

**principal meridian**–The meridian on which the PLS coordinates are based for a given region.

**prospect**–(1) A mineral property, the value of which has not been proved by exploration. (2) Nonproducing mining property under development or considered worthy of such attention.

**processing plant**–Facility for processing ore into concentrates, dore', or other intermediate products.

**pulp**–A mixture of ground ore and water capable of flowing through suitably graded channels as a fluid.

**pyrite**–Iron sulfide, $FeS_2$.

**pyrrhotite**–Iron sulfide, $Fe_{1-x}S$.

**quadrangle**–The USGS 1:250,000 (1 x 2°) map series.

**quarry**–A surficial opening or pit from which building stone, such as granite, marble, slate, etc., is extracted.

**radon**–A heavy, radioactive gas.

**range**–PLS coordinate expressed in 36-square mile increments east or west of the principal meridian.

**raw prospect**–A mineral location on which no significant exploration or other work has been done.

**reagent**–A chemical or solution used to produce a desired chemical reaction; a substance used in assay or flotation.

**retort**–A device used to distill off and recover mercury from amalgam.

**rib**–The side of a pillar or the wall of a mine entry.

**rind, rinding, weathering rind**–Weathered surface of rock.

**rockfall**–The relatively free-falling of a detached segment of bedrock of any size from a cliff, steep slope, cave, or arch.

**rod mill**–A mill for fine grinding employing long steel rods to grind the material.

**roentgen**–A measure of X-ray or gamma ray radiation.

**roentgen equivalent man (REM)**–A unit of absorbed radiation dose in humans.

**rougher flotation cell**–The primary cell(s) in a flotation mill. Typically, discharge from the rougher cells is directed to "cleaner," or secondary cells, for further treatment.

**SAG mill; semiautogenous grinding**–A grinding mill in which a portion of the grinding is accomplished by attrition of the material being ground. Grinding is aided by the addition of steel balls or rods.

**section**–PLS coordinate of a 1-square mile portion of the 36-square mile area defined by township and range.

**section subdivision**–PLS coordinate expressed as 1/4, 1/16, or 1/64 of a section.

**sediment**–Solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site of origin by air, water, or ice and has come to rest on the earth's surface either above or below sea level.

**sedimentation**–The settling of solid particles of soil, coal, or minerals from liquid as a result of either gravity or centrifuging.

**shaft**–An excavation of limited area compared with its depth, made for access to underground mine workings. Used for hoisting and lowering men and material, or ventilating underground workings.

**sluice; sluice box**–A long trough-like box set at an angle of about 1 in 20 through which placer gravel is carried by a stream of water. The gravel is washed away while most of the gold or other heavy materials are caught by riffles or blankets on the floor of the sluice.

**slurry**–Fine solid particles suspended in a liquid, typically water, of a consistency that allows flow by gravity or pumping.

**solution mining well**–See "well."

**solution pond**–A pond, usually associated with heap leaching operations, used to hold either pregnant (metal-bearing) or barren leach solutions.

**sphalerite**–Zinc-iron sulfide, (Zn,Fe)S.

**stamp battery; gravity stamp**–A machine for crushing ore used particularly in gold milling. It consists essentially of a crushing member (composed of a stem, head, and shoe) which is dropped on a die, the ore being crushed in water between shoe and die. An important crushing machine in the past but now becoming obsolete.

**stamp mill**–An apparatus (also the building containing the apparatus) in which rock is crushed by a stamp battery.

**stibnite**–Antimony sulfide, $Sb_2S_3$.

**stockpile**–A pile of ore set aside for future processing.

**stope**–An underground excavation from which ore has been removed.

**subsidence**–A sinking of a part of the earth's surface due to the collapse of underlying underground openings.

**sulfide**–A group of minerals in which metallic ions are combined with sulfur.

**sump**–An excavation in a mine used to collect water.

**surface-underground mine**–A mining operation that uses a combination of surface and underground mining methods.

**table; vibrating table; concentrating table**–A rectangular table equipped with riffles that concentrates gold or heavy minerals through vibration of material in a stream of water.

**tailings pond**–A pond with a constraining wall or dam to which mill effluents are run. Clear water may be returned after settlement, via penstock(s) and piping.

**tailings**–The refuse material resulting from the washing, concentration, or treatment of ground ore. The term, as used in the mineral industry, is used in the plural form.

**timber**–Any of the wooden props, posts, bars, collars, lagging, etc., used to support mine workings.

**township**–PLS coordinate expressed in 36-square mile increments north or south of the base line associated with the principal meridian.

**tram**—(1) A small wagon, tub, etc., for carrying minerals. (2) A boxlike wagon, running on a tramway or railway in a mine, for conveying coal or ore.

**tramway**—(1) A roadway having plates or rails on which wheeled vehicles may run. (2) A suspended cable system along which material, such as ore or rock, is transported in suspended buckets.

**tunnel**—A horizontal or nearly horizontal underground passage that is open to the atmosphere at both ends. The term is loosely applied in many cases to an adit. An adit, if continued through a hill, would then be a tunnel.

**type of operation**—The type of mining/milling operation that exists or has existed on a site.

**underground mine**—A mine wherein ore is extracted using underground mining methods. Contrast with "surface mine."

**waste**—The barren rock in a mine. It is also applied to the part of the ore deposit that is too low in grade to be of economic value at the time. This material may be stored separately in the event that it may become economic in the future.

**waste dump; spoil pile**—The area where mine waste or spoil materials are discarded.

**well**—Borehole used in solution mining or extraction of oil, gas, or geothermal water or steam.

**winze**—A vertical or inclined opening or excavation connecting two levels in a mine, differing from a raise only in construction. A winze is driven downward and a raise is excavated upward. When the connection is completed, the opening is referred to as a winze at its top and as a raise at its bottom.

**xanthate**—Common specific promoter used in flotation of sulfide ores.

## APPENDIX B.–TYPICAL MINERAL PROCESSING METHODS

Mine-run ore, with a few exceptions, must be "beneficiated" prior to further processing. "Beneficiation," commonly referred to as "milling," is the processing of ores for the purpose of (1) regulating the size of a desired product, (2) removing unwanted constituents, and (3) improving the quality, purity, or assay grade of a desired product.

Ore processing methods may be as simple as washing, screening, and drying, as in the case of sand and gravel, or highly complex as in multi-product flotation of copper, lead, zinc, silver, and gold ores.

For purposes of AML site investigations, four typical processing methods are discussed. These include amalgamation, gravity milling, two-product flotation, and heap and vat leaching.

### Amalgamation

The amalgamation gold recovery method has been used throughout the world for hundreds, perhaps thousands, of years. In the United States it was commonly used from colonial times until the 1960s and was widely used in conjunction with sluice operations or associated with stamp mills or other methods of liberating free gold from the host rock.

Gold (and other metals), when brought into contact with metallic mercury, will "amalgamate;" i.e., the liquid mercury will alloy with the surface gold to form a mercury-coated particle which has surface properties similar to those of pure mercury. The amalgamated particles will coalesce or cling together much as drops of pure mercury will collect into a single puddle. When mercury has amalgamated as much gold as possible, the result is a gray plastic mass of "amalgam." When heated in a retort, the mercury is distilled off leaving behind metallic gold ("sponge gold").

Larger amalgamation operations commonly used amalgamation plates for recovering gold. These are copper plates heavily coated with mercury (copper also amalgamates with mercury). Placer material or crushed gold ore is washed over the plate(s) as a thin pulp. The heavy gold particles fall to the bottom and are amalgamated by the mercury. When the mercury is saturated with gold, it is scraped off and new mercury applied to the plates. The amalgam is squeezed through canvas or chamois to remove excess mercury prior to retorting. Mercury vapor from the retort is condensed and reused. Amalgamation of high-grade ore or concentrates often was accomplished by agitation with mercury in a revolving barrel (barrel amalgamation).

Smaller operations and individual miners often placed liquid mercury directly into sluices or gold pans. When the mercury was saturated, it often was heated in the pan over an open fire, thereby discharging mercury vapor directly into the atmosphere. Eventually the mercury vapor condensed to the liquid state and fell onto vegetation, the ground, or into surface waters. In many instances, metallic mercury was, by virtue of accident or inefficient operating procedures, spilled on the ground or washed into streams or other surface waters.

It could be argued that mercury contamination, because of its toxicity and persistence, presents the greatest hazard when considering mineral process-related contamination.

Indications of possible amalgamation operations include, but are not limited to, wooden or metal troughs up to several meters in length ("long toms"--the troughs may or may not have cleats or "riffles" at regular intervals normal to the longitudinal axis), large copper trays attached to sluices or troughs, presence of mercury flasks, liquid mercury in adjacent streams or other surface waters, stamp mills, Chilean mills, or arrastres.

Figure B-1 is a Chilean mill at an abandoned mine in Alaska; figure B-2 shows the remains of an arrastre (arrastre; arrastra . . . a circular rock-lined pit in which broken ore is pulverized by stones attached to a pillar and dragged around the pit. The arrastre was in common use in the western and southwest United States in the 18th and 19th centuries.)



**Figure B-1.–Chilean mill.**

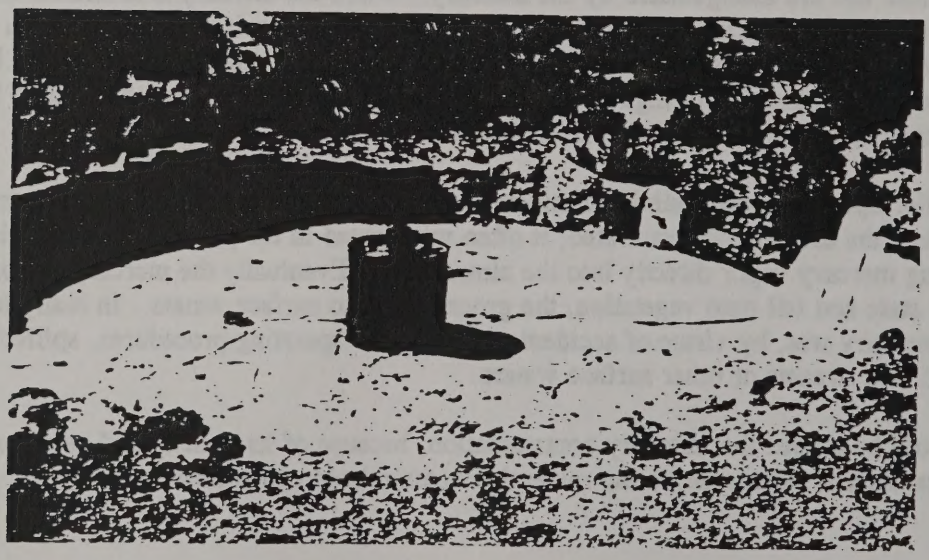


**Figure B-2.–Remains of an arrastre.**

Figure B-3 illustrates a stamp battery, a part of a stamp mill. It is not very often that a battery is found in this good of condition. More likely only the remains, or parts, are encountered as shown in figure B-4--note the stamp rods in the left-center of the photograph and compare to figure B-3.



**Figure B-3.–Stamp battery.**



**Figure B-4.–Stamp rods are evidence of a former stamp mill.**

## Gravity Mill

Gravity mills often are used to separate heavy minerals such as garnet, ilmenite, and scheelite or heavy metals such as gold from the waste rock. Depending on the nature of the ore, the process may or may not include a flotation circuit.

The following description and flowsheet of a typical gravity mill are repeated from Camm, p. 24:

> Mine-run ore is initially crushed by a jaw crusher. The discharge is sent to a double-deck screen where the plus 1.9-cm (3/4 in) fraction discharges onto a conveyor belt and is fed to a cone crusher. The minus 1.9-cm (3/4 in) fraction from the jaw and cone crusher is conveyed to vibrating screens. Oversize from the screens is returned to the cone crusher and the undersize is slurried and fed to the jig.
>
> Tails from the jig go to the rod mill where grinding occurs in closed circuit with a cyclone classifier. Overflow from the cyclone is pumped to a spiral classifier. Size fractions from the classifier are sent to a series of tables to produce a high-grade concentrate, a middling product, and tailings. The middlings are combined and recycled through the rod mill.
>
> Table concentrates are sent to a flotation cell where any sulfides present are floated off. Underflow from the float cell is combined with the concentrates from the jig and then thickened and dried. Tailings are thickened and sent to the tailings pond.

A simplified flowsheet for the gravity mill is presented in figure B-5.

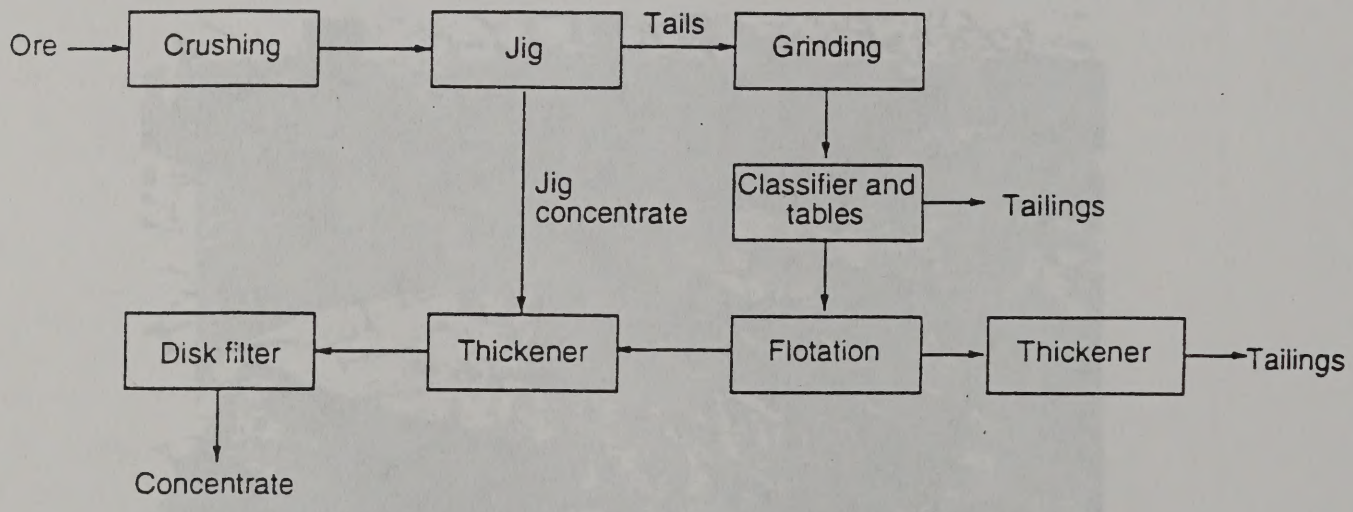



**Figure B-5.–Gravity mill flowsheet.**

Indications of a possible gravity mill include, but are not limited to the presence of a mineral jig, cyclone or spiral classifiers, or concentrating tables. Figures B-6 and B-7 illustrate a mineral jig and a concentrating table, respectively.



Figure B-6.–Mineral jig. (Courtesy Curtis Tungsten, Inc.)

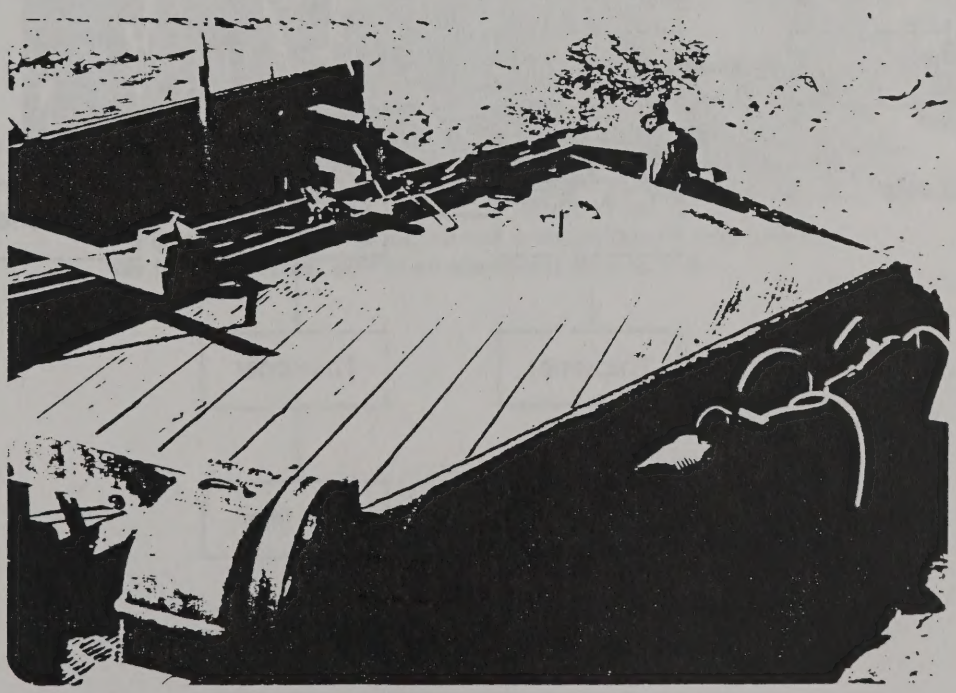


Figure B-7.–Concentrating table. ( Courtesy Curtis Tungsten, Inc.)

## Two-Product Flotation Mill

Flotation is a method of mineral separation in which a number of reagents (frothers, activators, depressants, collectors, and conditioners) selectively floats or sinks finely crushed minerals in an enclosed flotation cell. The process is particularly amenable to base metal sulfides. The types of reagents usually associated with flotation mills are presented on table 1 in the text.

The following description of a two-product flotation mill and associated flowsheet is repeated from Camm, p. 22.

Mine-run ore is initially crushed and sized in a series of crushers and vibration screens to approximately minus 1.6 cm (5/8 in). Crushed ore is then ground in rod mills and passed through cyclones. The oversize is ground in ball mills then pumped back to the cyclones to achieve a minus 200 mesh flotation feed. Cyclones undersize is sent to the first product rougher flotation cells. These rougher concentrates pass to cleaner cells where they are further concentrated. Tails from the cleaner cells and middlings from the rougher cells are recirculated through the first flotation circuit. Concentrates from the cleaner cells are thickened and dried prior to stockpiling for shipment.

Tails from the first product rougher cells flow to the second flotation circuit. Rougher concentrates are further treated in the second cleaner cells. As with the first product circuit, tails from the cleaner cells and middlings from the rougher cells are recirculated through the second product flotation circuit. Tails from the rougher cells are sent to the tailings pond and the concentrates are thickened, dried, and stockpiled for shipment.

A flowsheet for a typical two-product mill is presented in figure B-8.

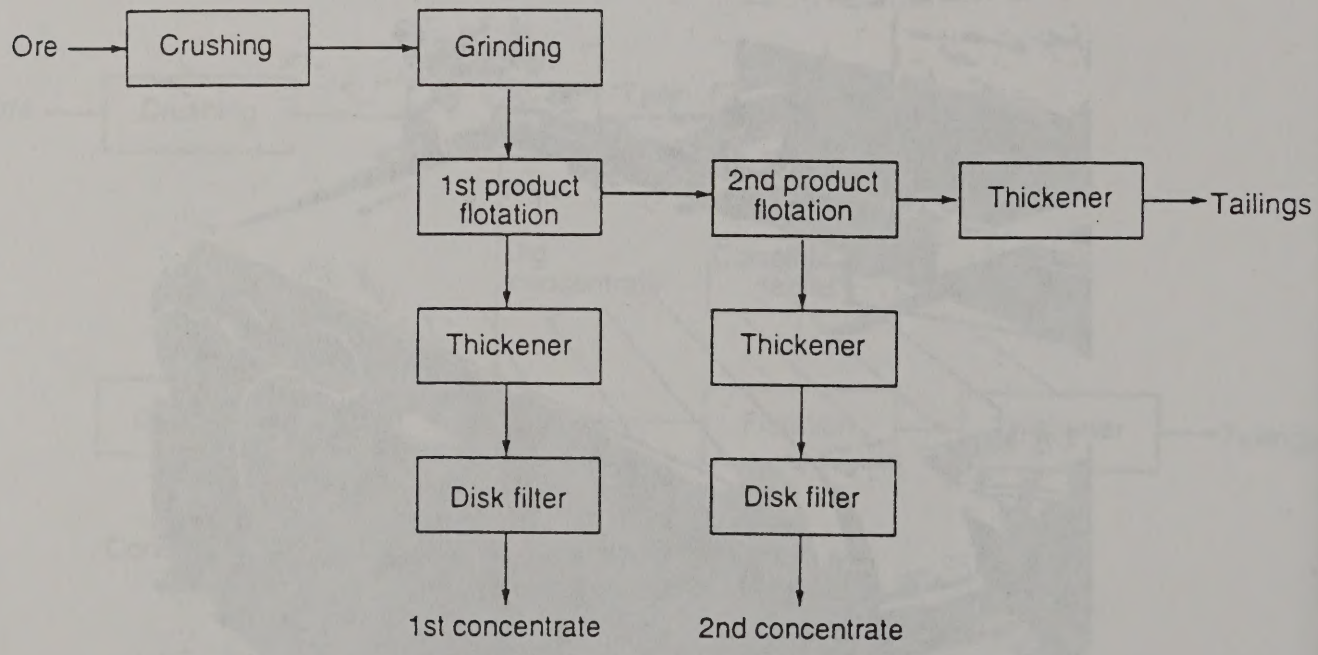



**Figure B-8.–Typical flotation mill flowsheet, two-product.**

Indications of a possible flotation mill (1-, 2-, or 3-product) include, but are not limited to the presence of flotation cells, conditioning tanks, and barrels, bins, or other containers whose markings may indicate their use for transport or storage of reagents associated with flotation operations. Common reagents used in flotation include, but are not limited to, xanthate, pine oil, sodium cyanide (NaCN), lime (calcium oxide--CaO), alum, alcohol frothers, among others (fig. B-9). Refer to table 1 in the text for an expanded list of reagents under the heading "Sulfides."

Figure B-10 shows a bank of flotation cells; figure B-11 illustrates a ball mill and classifier. A thickener, used for dewatering, is illustrated in figure B-12.



**Figure B-9.–Labels on barrels and other containers may indicate the type of reagents used at an abandoned mine or mill.**

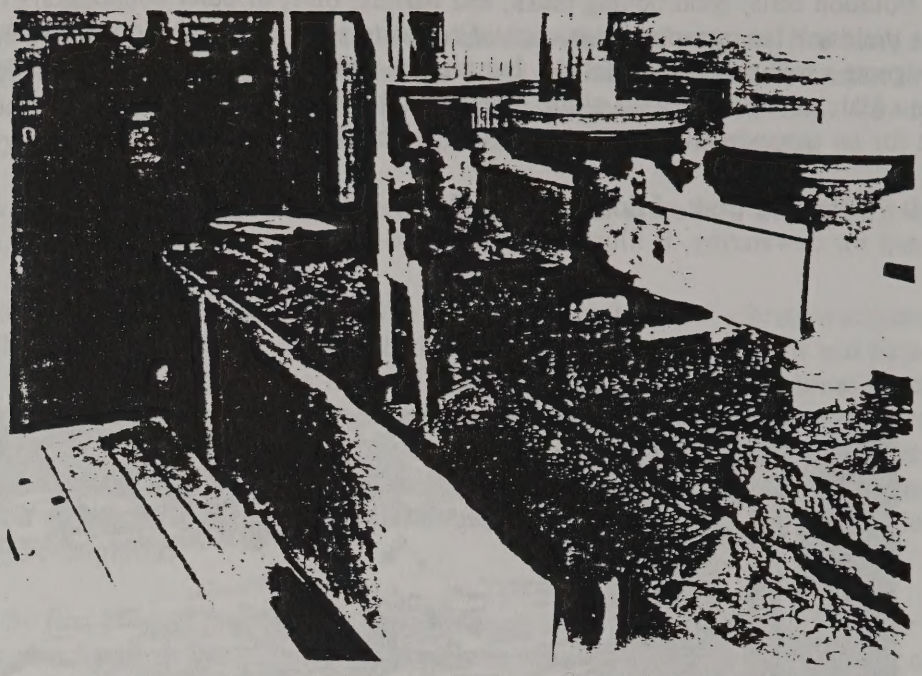


Figure B-10.–Bank of flotation cells.

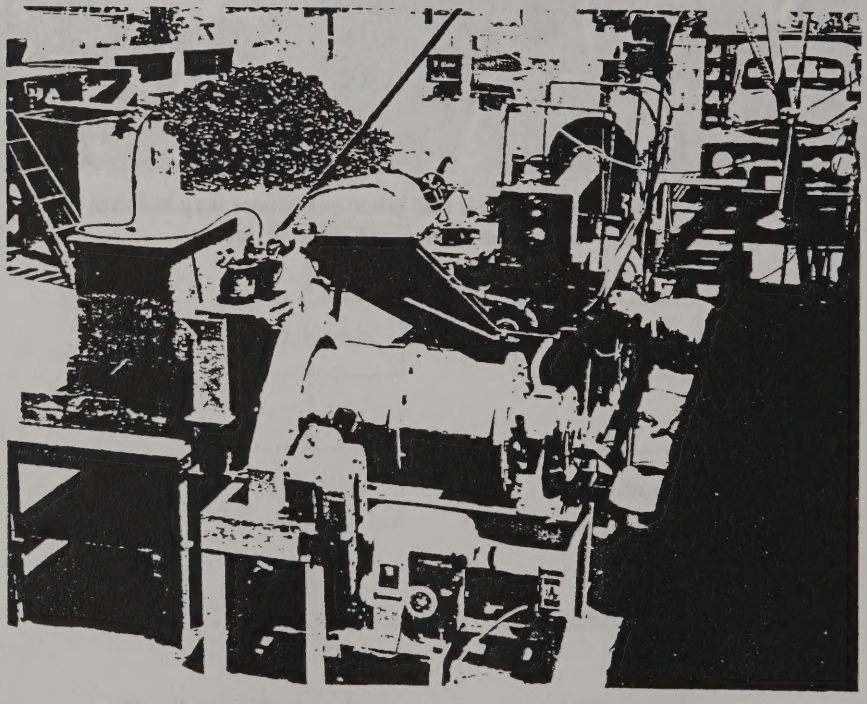


Figure B-11.–Ball mill and classifier.

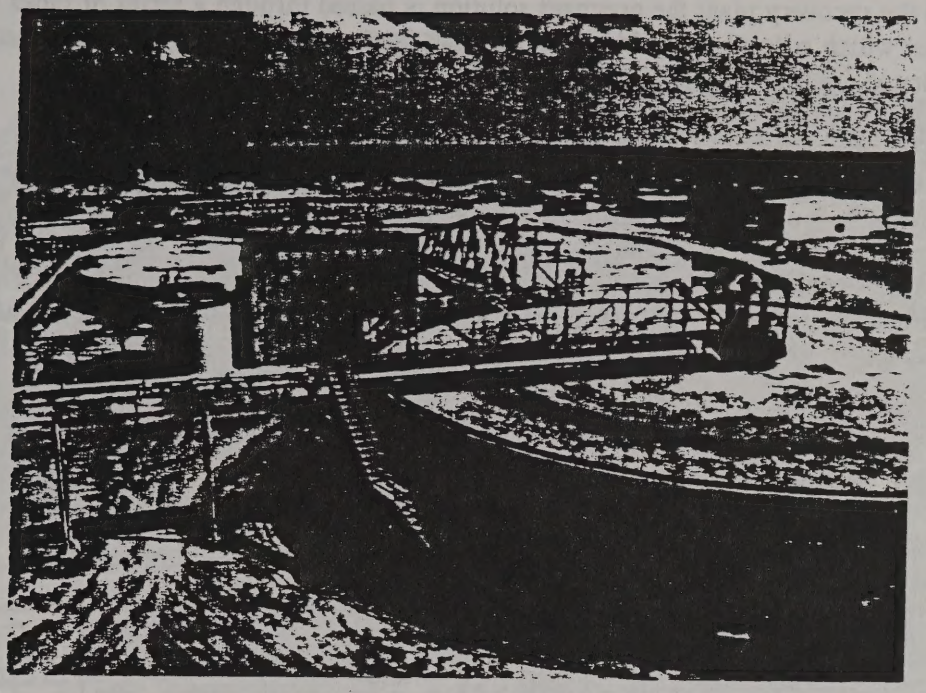


**Figure B-12.–Thickener.**

## Heap-Vat Leach Mill

Heap and vat leach processes use a chemical property of cyanide (in some cases acid or other solvents) to dissolve metal values from ore. Metal values contained in the cyanide solution are subsequently adsorbed on activated charcoal, stripped from the charcoal by a hot caustic solution, electroplated on steel wool cathodes, then smelted to produce a dore' product.

Cyanide leaching processes were employed in Nevada and southern California near the turn of the century primarily to recover silver; modern leaching practices are essentially improved variations on the older methods. Today the most widely applied leach process is the heap leach method which is generally used for lower grade oxide ores. In instances where a mine has both oxide (generally lower grade) and sulfide ores (generally higher in grade), two or more processes may be used. The low-grade ore is typically processed by heap leaching, the higher grade ore by carbon-in-leach (CIL), carbon-in-pulp (CIP), or other methods. Depending on ore characteristics, cyanidation may be used by itself or in combination with other processes such as gravity and flotation. With hard-to-process ores, other processes such as oxidation, chlorination, and autoclaving may be used in conjunction with cyanide leaching.

## Heap Leaching

Mine-run ore is generally crushed and screened, then hauled by truck to the leach pads where bulldozers are commonly used to level and contour the pile. A cyanide solution is sprayed on the ore and percolated through the heap dissolving metal values in passing. The metal-laden solution ("pregnant solution") is routed through a series of pipes or lined ditches to a pregnant solution pond. From the pond the solution is pumped or flows by gravity to the recovery plant.

In the recovery plant the pregnant solution is passed through a series of tanks containing activated charcoal which adsorbs the gold. Alternatively, in the Merrill-Crowe process, metal values are precipitated from the solution using zinc dust.

When the charcoal becomes saturated, it is treated with a hot caustic solution to dissolve the gold which is then electroplated onto steel wool cathodes. The cathodes are smelted to recover gold and other metallic constituents in bullion form referred to as "dore'."

A flowsheet for a typical heap leach operation is presented in figure B-13. Figure B-14 illustrates a typical heap leach operation. At the toe of the heap (to the left) can be seen the pregnant solution collection ditch and associated piping. To the left of the collection ditch are the pregnant and barren solution ponds.

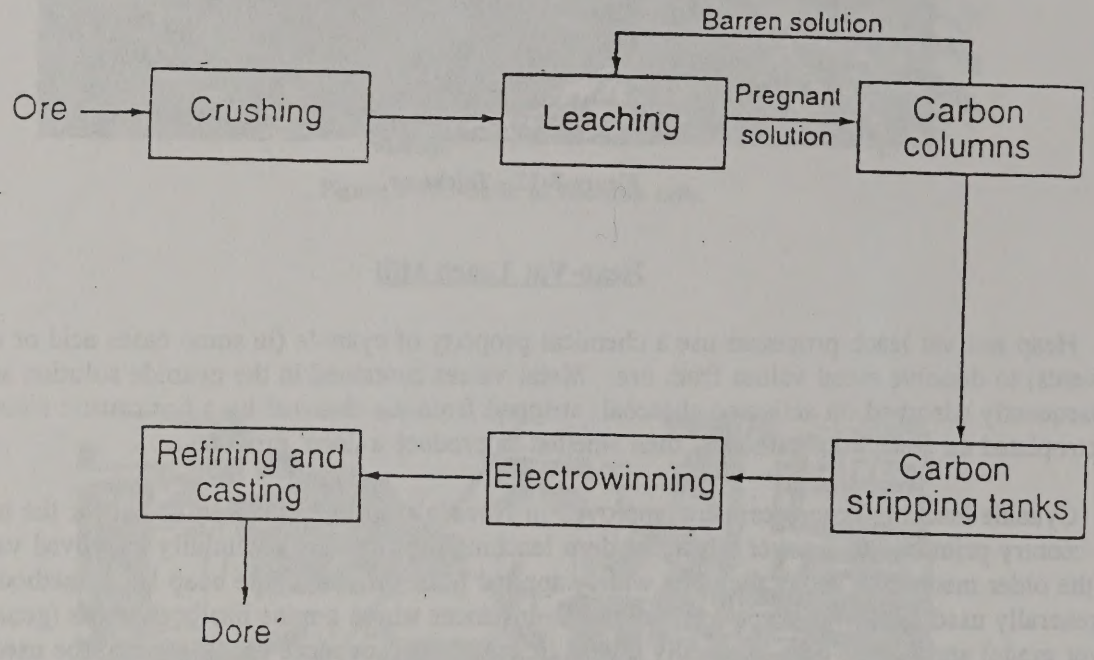



**Figure B-13.–Heap leach flowsheet.**

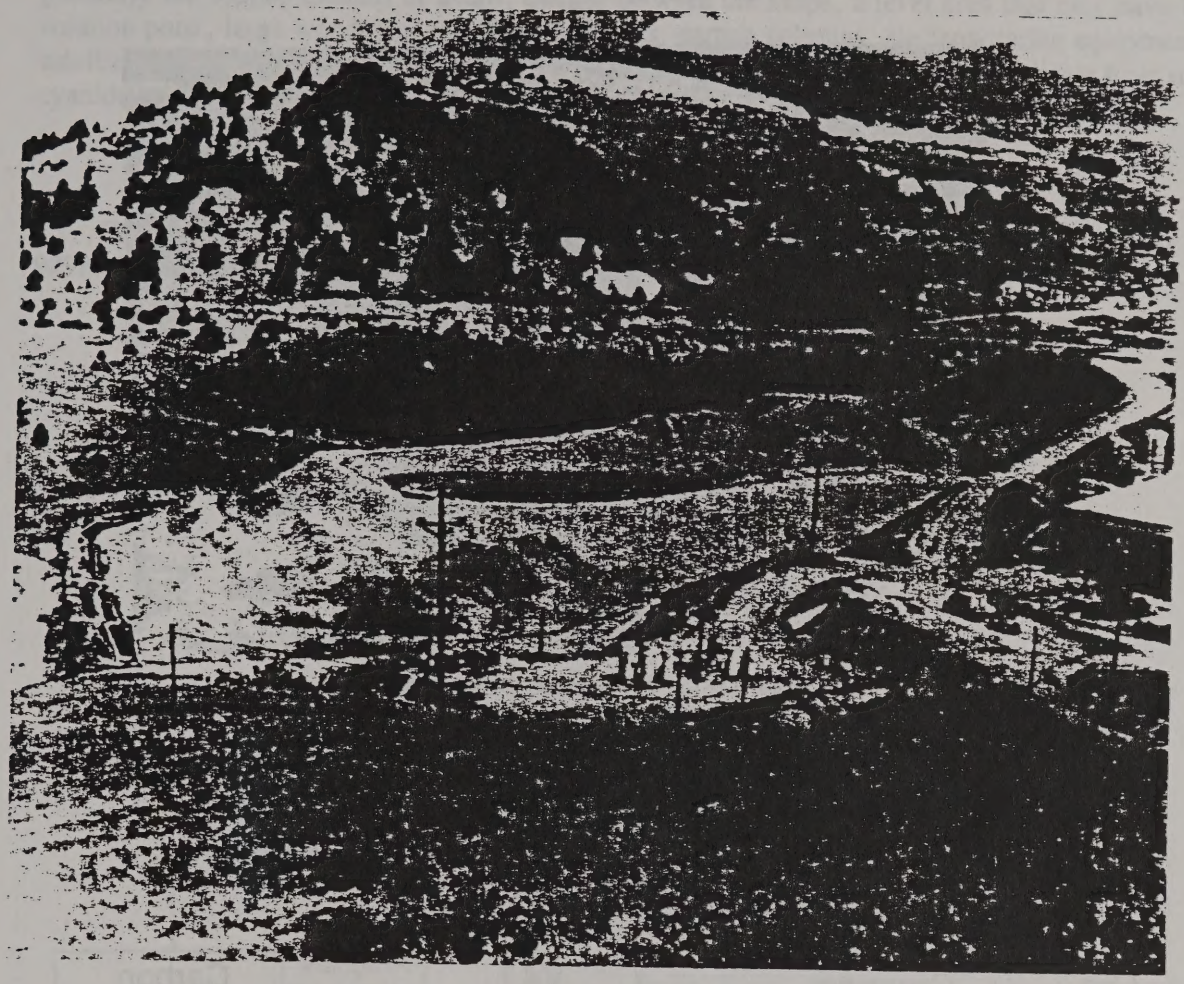


**Figure B-14.–Typical heap leach operation.**

## Vat Leaching

Vat leaching is very similar to heap leaching except that instead of the ore being leached on a heap, it is leached in a series of vats. The metal recovery method is generally the same as heap leach recovery.

Figure B-15 shows the remains of a vat leach operation; a flowsheet for vat leaching is presented in figure B-16.

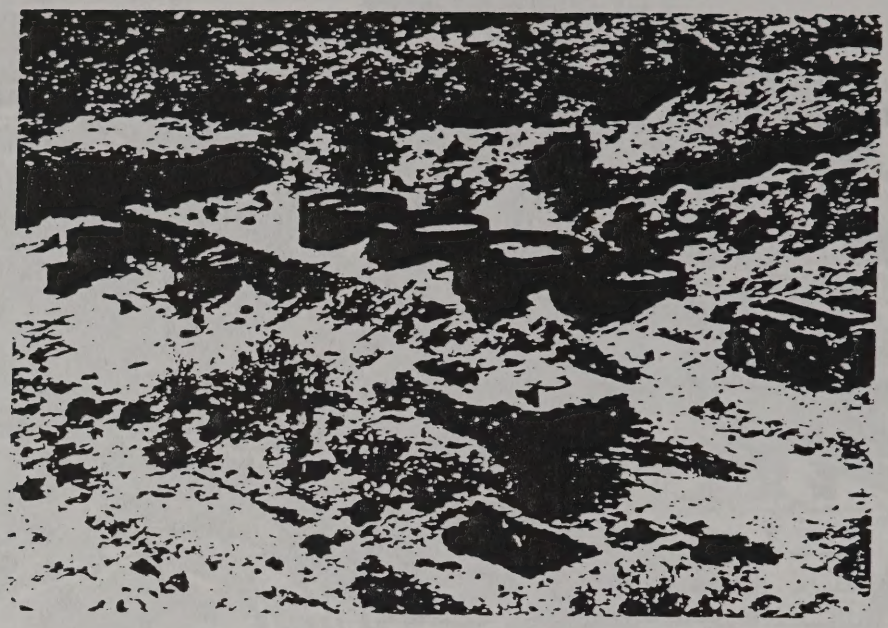


Figure B-15.–Remains of vat leach mill.

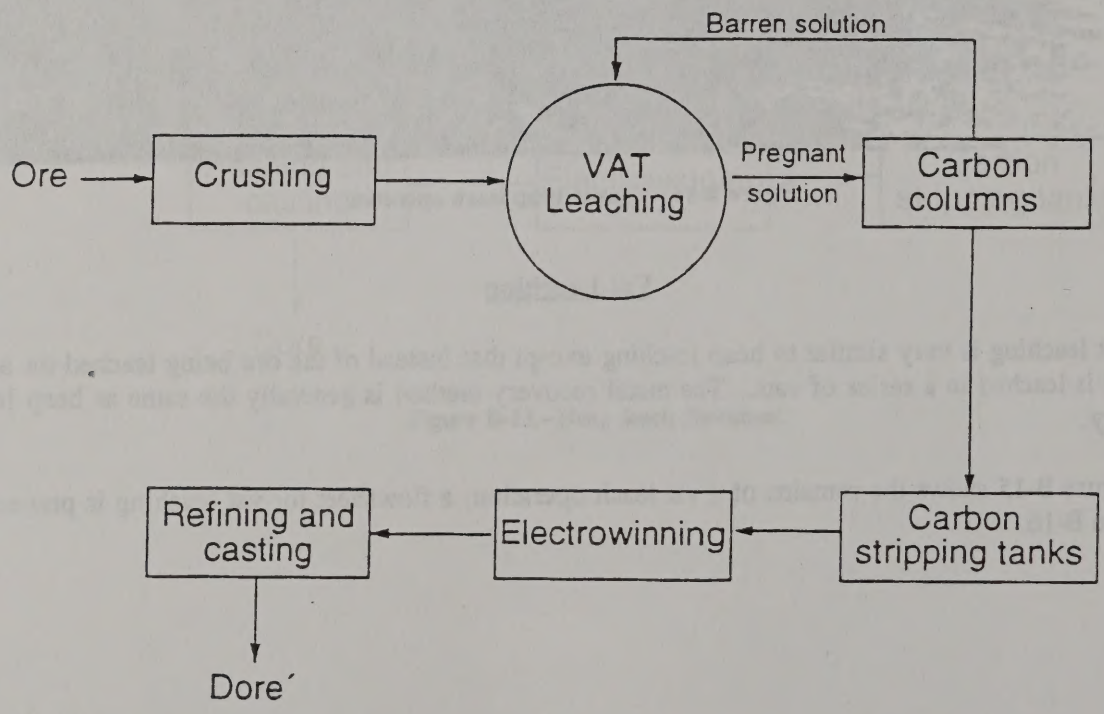



Figure B-16.–Vat leach flowsheet.

Indications of a possible heap/vat leach mill include, but are not limited to, large or small, generally flat-topped mounds or heaps, ditches between the heaps, a level area that may have been a solution pond, large wooden or metal tanks or vats, carbon columns, electrowinning equipment, or smelting-casting furnaces. Markings on barrels, bins, or other containers may indicate their use for cyanide transport or storage.

## Reference Cited

1. Camm, T. W. Simplified Cost Models for Prefeasibility Mineral Evaluations. BuMines IC 9298, 1991, 35 pp.

# APPENDIX C.–AML INVENTORY AND INVESTIGATION FORM

U. S. Bureau of Mines

AML INVENTORY FORM EVALUATOR

Part I - Pre-Field Data (Side 1) PAGE 1 OF

SITE NUMBER DATE OF INVESTIGATION

## 1) PROPERTY NAME:

Alternate Names

MILS Sequence No. MRDS No.

BOM Mineral Property File No.

State ID No. EPA ID No.

## 2) OWNERSHIP:

What is the current ownership of the site? Check one.

Federal Indian State County Municipal Private/Patented

Unknown Other

If the owner is known, fill in the following information.

Name or Agency

Address

Telephone Number - -

Ownership includes Surface only Minerals only Both

## 3) LOCATION DATA:

Fill in location information as available.

State County

Township N S Range E W Section

Section Subdivision Meridian

Latitude Longitude

UTM Zone Northing Easting

Elevation Specify units for elevation. Feet Meters

Map Name Map Scale

1:250,000 Quadrangle

Mining District

Approximate area of site Measured in Square feet Acres Hectares

## 4) HISTORICAL DATA:

Check all that apply.

### Type of Operation:

Surface Underground Surface-Underground Mineral Location Placer

Prospect Dredge Processing Plant Well Unknown No Data

### Status of Operation:

Past Producer Explored Prospect Raw Prospect Unknown

Developed Prospect (greater than 300 meters of workings)

U.S. Bureau of Mines

AML INVENTORY FORM EVALUATOR

Part I - Pre-Field Data (Side 2) PAGE 2 OF

SITE NUMBER DATE OF INVESTIGATION

## 4) HISTORICAL DATA (Continued.) Check all that apply.

### Commodities:

Arsenic Cadmium Copper Lead Mercury Zinc

Other (specify)

### Commodity Groups:

Metals Coal Oil and Gas Uranium or Geothermal

Industrial Minerals Sand and Gravel Non-Energy Leasable

Other (specify)

### Acid Producers or Indicator Minerals:

Arsenopyrite Chalcopyrite Galena Marcasite Sphalerite Sulfide

Iron Oxide Limonite Pyrite Pyrrhotite Stibnite

### Size/Production: Indicate the total amount of ore produced to date in metric tons (mt).

Small (0-10,000 mt) Small-Medium (10,000mt-250,000mt) Medium (250,000mt-500,000mt)

Medium-Large (500,000mt-1,000,000mt) Large (Over 1,000,000mt)

### Mill Method:

Amalgamation Arrastre Gravity Crusher (only) Heap Leach Leach

CIP (Carbon-in-Pulp) Cyanidation Stamp Flotation Jig Plant Retort

No Mill Unknown

### Neutralizing Host Rock:

Carbonate Dolomite Limestone Marble

### Workings/history: Indicate size, number, and type of mine openings, if available.

### Years of Operation: From To

### Annual Precipitation: Check one.

Less than 25 centimeters More than 25 centimeters

## 5) SPECIALTY DATA: Check all that apply.

### Site in a known or suspected floodplain:

None Annual - 10 years 10 - 100 years 100 - 500 years Less than once every 500 years

### Threatened and Endangered Plants and Animals:

a) Are any threatened and/or endangered plants and/or animals on or near the site? Circle one. YES NO

b) If present, list type(s).

## COMMENTS:

U. S. Bureau of Mines

# AML INVENTORY FORM - SITE DATA

Part II - Field Data (Side 1)

INVESTIGATION DATE _____ PAGE ____ OF ____

GPS LOCATION _____

SITE NUMBER _____ SITE NAME _____

EVALUATOR _____ AGENCY _____

ADDRESS _____ TELEPHONE _____

## 1) NEAREST SITE(S) OF HUMAN ACTIVITY (Give distance, circle units, or mark N/A)

Dwelling(s) ____ km mi | School ____ km mi | Workplace ____ km mi

Campground ____ km mi | Trail ____ km mi | Road ____ km mi

## 2) SENSITIVE ENVIRONMENTS (If any, give name or distance, if known) Circle one per group

| | | | | |
|---|---|---|---|---|
| a) Threatened and Endangered Species | _____ | UNK | YES | NO |
| b) Wetlands | ____ km mi | UNK | YES | NO |
| c) Fisheries | ____ km mi | UNK | YES | NO |
| d) Other | ____ km mi | UNK | YES | NO |

## 3) WATER Are bodies of water found on or within 2 mi (3.2 km) of the site? Circle one, and check all that apply. YES NO

Stream ☐ River ☐ Pond ☐ Lake ☐ Bay ☐ Other _____

Name of nearest water body _____ Distance ____ km mi

## 4) AIRBORNE POLLUTANTS Circle one per group

| | | | | |
|---|---|---|---|---|
| a) Dust | | UNK | YES | NO |
| b) Spray | | UNK | YES | NO |
| c) Vapor | | UNK | YES | NO |
| d) Other | Name _____ | UNK | YES | NO |

## 5) RADIATION Did pre-field research indicate this area has produced uranium? Circle one. YES NO

If yes, take radiation reading and record value. _____ Counts per second (cps)

## 6) EXPLOSIVES Are any explosives or blasting supplies found on the site? Circle one. UNK YES NO

If present, list type and location. _____

## 7) OTHER Are any of the following present? Check all that apply, provide comments as necessary below.

| | | | | |
|---|---|---|---|---|
| Acrid Odor ☐ | Drum(s)/Tank(s) ☐ | Overhead Wire(s) ☐ | Power Substation(s) ☐ | Tramway(s) ☐ |
| Antennas ☐ | Fence(s) ☐ | Pipe(s) ☐ | Scrap Metal ☐ | Transformer(s) ☐ |
| Aviation Hazard(s) ☐ | Flume(s) ☐ | Pole(s) ☐ | Tower(s) ☐ | Trestle(s) ☐ |
| Bag(s) ☐ | Headframe(s) ☐ | Power Line(s) ☐ | Tram Bucket(s) ☐ | Wooden Structure(s) ☐ |
| Chemical(s) ☐ | Overhead Cable(s) ☐ | Other (specify) _____ | | |

Site appears to have cultural significance or value ☐ (Check if yes)

## 8) PHOTOGRAPH NUMBERS

## 9) SKETCH NUMBERS

## COMMENTS

U. S. Bureau of Mines

# AML INVENTORY FORM - FEATURE DATA

Part II - Field Data (Side 2)

INVESTIGATION DATE _____ PAGE ____ OF ____

SITE NUMBER _____ SITE NAME _____

## 10) FEATURE

Number _____ Fill out one form per feature. Check appropriate box below.

| | | | | | |
|---|---|---|---|---|---|
| Adit ☐ | Decline ☐ | Machinery ☐ | Ore Stockpile ☐ | Quarry ☐ | Stope ☐ |
| Building ☐ | Glory Hole ☐ | Mill Building ☐ | Pit, Large, >3 m ☐ | Shaft ☐ | Subsidence ☐ |
| Cistern ☐ | Highwall ☐ | Mill Tailings ☐ | Pit, Small, <3 m ☐ | Solution Mining Well ☐ | Sump ☐ |
| Crosscut ☐ | Leach Pad ☐ | Mine Dump ☐ | Placer Mine ☐ | Solution Pond ☐ | Trench ☐ |
| Other _____ | | | | | Tunnel ☐ |

## 11) CONDITION

Does the condition of the above identified feature represent a physical hazard? Circle one. YES NO

Check the conditions that best describe the physical character of the above feature.

| | | | | | |
|---|---|---|---|---|---|
| Breached ☐ | Collapsed, Partial ☐ | Empty ☐ | Foundation ☐ | Standing ☐ | Unstable Walls ☐ |
| Caved ☐ | Concealed ☐ | Eroded ☐ | Intact ☐ | Subsided ☐ | Wind Erosion ☐ |
| Caved, Partial ☐ | Concealed, Partial ☐ | Eroded, Partial ☐ | Open to Entry ☐ | Unconfined ☐ | |
| Collapsed ☐ | Confined ☐ | Fenced ☐ | Rotten Cribbing ☐ | Other _____ | |

## 12) SIZE OF FEATURE

Indicate size of feature and specify units (feet or meters).

Length _____ X Width _____ X Depth or Height _____

Measurement: Actual ☐ Estimate ☐ Feet ☐ Meters ☐

Slope (Degrees) ____ Bank Stability: Stable ☐ Unstable ☐ Marginally Stable ☐

## 13) WATER

Is water present at the feature? Circle one. YES NO

Is water emanating from or passing through the feature? Circle one. YES NO

a) If water is present, how does it occur? Check all that apply.

Standing ☐ Filled ☐ Partly Filled ☐ Flowing ☐ Intermittent ☐

b) If present, determine: GPM: _____ Conductivity : _____ pH: _____

c) Observe water bed color. (Check all that apply, or specify other.)

Brown ☐ Green ☐ Yellow ☐ Yellow-orange ☐ Orange ☐ Gray-black ☐ Other (specify) ☐

## 14) PLANTS

Are plants present on or around the feature? Circle one. YES NO

If yes, check one.

Healthy ☐ Stressed ☐ Dead ☐ Barren ☐ Partial Revegetation ☐ Full Revegetation ☐ Other (specify) ☐

## 15) STAINING

Stains may indicate spills, oxidation, or alteration. Are non-water-related stains present? YES NO

If stains are present, check appropriate color or specify other. Yellow-orange ☐ Gray-black ☐ Other (specify) ☐

## 16) MACHINERY

Is machinery present at this feature? Circle one. YES NO

a) Location of machinery. Check all that apply.

Inside Building ☐ No Building ☐ Outside Building ☐ Other (specify) _____

b) Type of machinery. Check all that apply or specify other.

| | | | | |
|---|---|---|---|---|
| Amalgamation Equipment ☐ | Crusher(s) ☐ | Ore Bin(s) ☐ | Stamp Mill(s) ☐ | Vat(s) ☐ |
| Arrastre ☐ | Flotation Cell Group ☐ | Retort(s) ☐ | Tank(s) ☐ | |
| Ball Mill(s) ☐ | Leach Tank(s) ☐ | Rod Mill(s) ☐ | Thickener(s) ☐ | |

Others (specify) _____

## 17) PHOTOGRAPH NUMBERS

## 18) SKETCH NUMBERS

## COMMENTS

U.S. Bureau of Mines

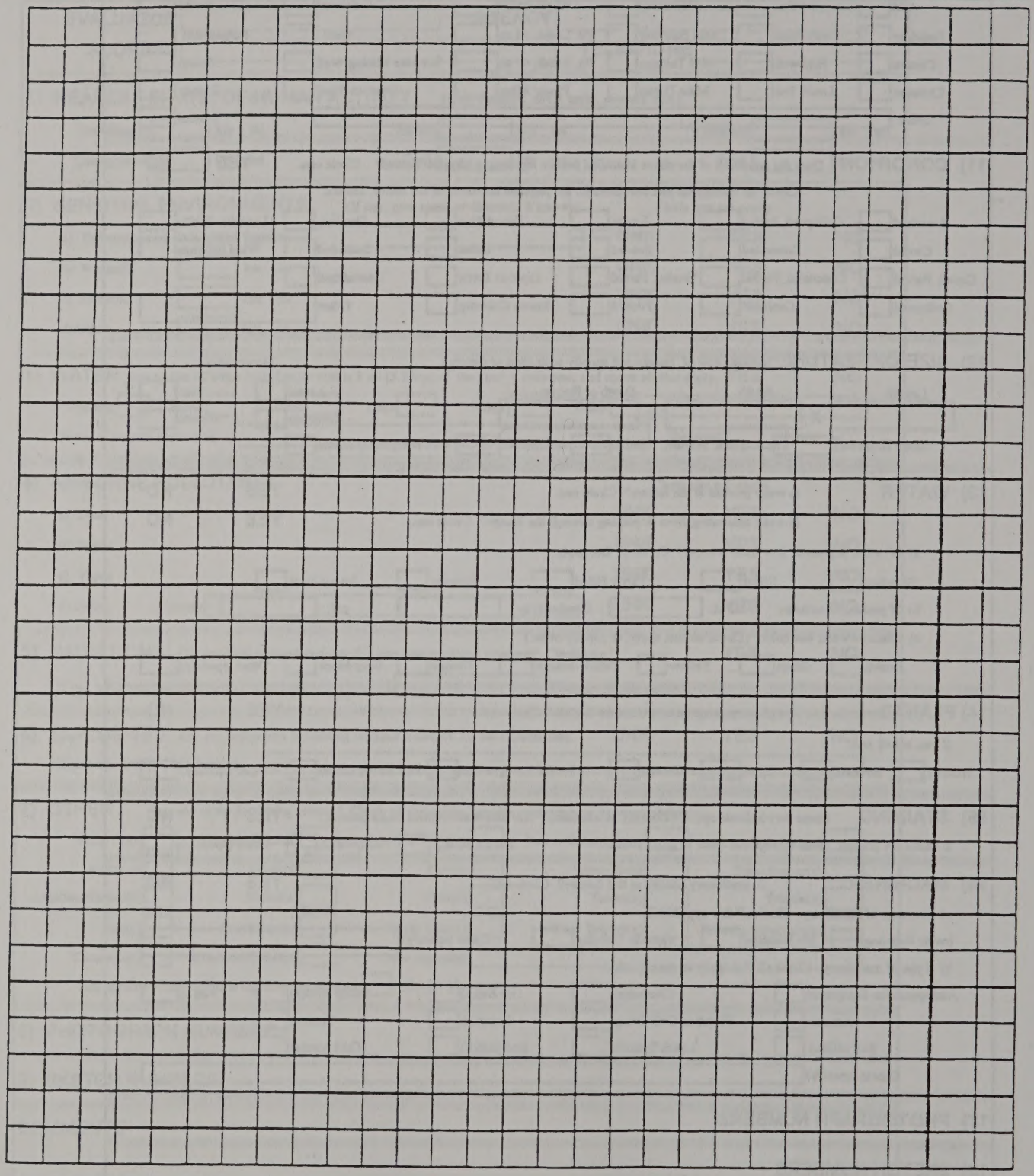
AML INVENTORY FORM

Part III - Supplemental Data (Notes, Sketches, Photographs, etc.)

PAGE ☐ OF ☐

SITE NUMBER ☐

DATE ☐



NOTE: Be sure to provide a north arrow and the scale on sketch maps.

U. S. Bureau of Mines

# AML INVENTORY FORM - SITE DATA

Part II - Field Data (Side 1)

INVESTIGATION DATE 4-26-93 PAGE 1 OF 3

GPS LOCATION N-5279169 E-556613

SITE NUMBER 016Ø799203 SITE NAME Grizzly Bear

EVALUATOR John DOE AGENCY USBM

ADDRESS E. 360 3rd Ave, Spokane, WA TELEPHONE (509)353-2700

## 1) NEAREST SITE(S) OF HUMAN ACTIVITY (Give distance, circle units, or mark N/A)

Dwelling(s) 5 km (mi) School N/A km mi Workplace N/A km mi

Campground N/A km mi Trail N/A km mi Road N/A km mi

## 2) SENSITIVE ENVIRONMENTS (If any, give name or distance, if known) Circle one per group

| | | | | |
|---|---|---|---|---|
| a) Threatened and Endangered Species | | (UNK) | YES | NO |
| b) Wetlands | km mi | UNK | YES | (NO) |
| c) Fisheries | km mi | (UNK) | YES | NO |
| d) Other | km mi | UNK | YES | (NO) |

## 3) WATER Are bodies of water found on or within 2 mi (3.2 km) of the site? Circle one, and check all that apply. YES NO

Stream [X] River [ ] Pond [ ] Lake [ ] Bay [ ] Other [ ]

Name of nearest water body Gold Creek Distance Ø.1 km (mi)

## 4) AIRBORNE POLLUTANTS Circle one per group

| | | | |
|---|---|---|---|
| a) Dust | UNK | (YES) | NO |
| b) Spray | UNK | YES | (NO) |
| c) Vapor | UNK | YES | (NO) |
| d) Other Name | UNK | YES | (NO) |

## 5) RADIATION Did pre-field research indicate this area has produced uranium? Circle one. (YES) NO

If yes, take radiation reading and record value. 80 Counts per second (cps)

## 6) EXPLOSIVES Are any explosives or blasting supplies found on the site? Circle one. UNK YES NO

If present, list type and location. Dynamite in adit near portal

## 7) OTHER Are any of the following present? Check all that apply, provide comments as necessary below.

| | | | | |
|---|---|---|---|---|
| Acrid Odor [ ] | Drum(s)/Tank(s) [ ] | Overhead Wire(s) [ ] | Power Substation(s) [ ] | Tramway(s) [ ] |
| Antennas [ ] | Fence(s) [ ] | Pipe(s) [ ] | Scrap Metal [ ] | Transformer(s) [ ] |
| Aviation Hazard(s) [ ] | Flume(s) [ ] | Pole(s) [ ] | Tower(s) [ ] | Trestle(s) [ ] |
| Bag(s) [ ] | Headframe(s) [ ] | Power Line(s) [ ] | Tram Bucket(s) [ ] | Wooden Structure(s) [ ] |
| Chemical(s) [ ] | Overhead Cable(s) [ ] | Other (specify) NONE | | |

Site appears to have cultural significance or value [ ] (Check if yes)

## 8) PHOTOGRAPH NUMBERS Ø16Ø799203-1

## 9) SKETCH NUMBERS 1, 2

## COMMENTS

Mine water flows into nearby creek.

U. S. Bureau of Mines — AML INVENTORY FORM - FEATURE DATA — Part II - Field Data (Side 2)

INVESTIGATION DATE 4-28-93 — PAGE 2 OF 3

SITE NUMBER CO60799203 — SITE NAME Grizzly Bear

**10) FEATURE** Number 1 — Fill out one form per feature. Check appropriate box below.

| | | | | | | |
|---|---|---|---|---|---|---|
| Adit [X] | Decline [ ] | Machinery [ ] | Ore Stockpile [ ] | Quarry [ ] | Stope [ ] |
| Building [ ] | Glory Hole [ ] | Mill Building [ ] | Pit, Large, >3 m [ ] | Shaft [ ] | Subsidence [ ] |
| Cistern [ ] | Highwall [ ] | Mill Tailings [ ] | Pit, Small, <3 m [ ] | Solution Mining Well [ ] | Sump [ ] |
| Crosscut [ ] | Leach Pad [ ] | Mine Dump [ ] | Placer Mine [ ] | Solution Pond [ ] | Trench [ ] |
| Other [ ] | | | | | Tunnel [ ] |

**11) CONDITION** Does the condition of the above identified feature represent a physical hazard? Circle one. YES NO

Check the conditions that best describe the physical character of the above feature.

| | | | | | |
|---|---|---|---|---|---|
| Breached [ ] | Collapsed, Partial [ ] | Empty [ ] | Foundation [ ] | Standing [ ] | Unstable Walls [ ] |
| Caved [ ] | Concealed [ ] | Eroded [ ] | Intact [ ] | Subsided [ ] | Wind Erosion [ ] |
| Caved, Partial [ ] | Concealed, Partial [ ] | Eroded, Partial [ ] | Open to Entry [X] | Unconfined [ ] | |
| Collapsed [ ] | Confined [ ] | Fenced [ ] | Rotten Cribbing [ ] | Other Wall Slough | |

**12) SIZE OF FEATURE** Indicate size of feature and specify units (feet or meters).

Length NA x Width 4 x Depth or Height 3

Slope (Degrees) N/A — Bank Stability: Stable [N/A] Unstable [ ] Marginally Stable [ ]

Measurement: Actual [X] Estimate [ ] — Feet [X] Meters [ ]

**13) WATER** Is water present at the feature? Circle one. YES NO

Is water emanating from or passing through the feature? Circle one. YES NO

a) If water is present, how does it occur? Check all that apply.

Standing [ ] Filled [ ] Partly Filled [ ] Flowing [ ] Intermittent [ ]

b) If present, determine: GPM: 9.35 Conductivity: 300 pH: 6.5

c) Observe water bed color. (Check all that apply, or specify other.)

Brown [ ] Green [ ] Yellow [ ] Yellow-orange [X] Orange [ ] Gray-black [ ] Other (specify) [ ]

**14) PLANTS** Are plants present on or around the feature? Circle one. YES NO

If yes, check one.

Healthy [ ] Stressed [ ] Dead [ ] Barren [ ] Partial Revegetation [X] Full Revegetation [ ] Other (specify) [ ]

**15) STAINING** Stains may indicate spills, oxidation, or alteration. Are non-water-related stains present? YES NO

If stains are present, check appropriate color or specify other. Yellow-orange [X] Gray-black [X] Other (specify) [ ]

**16) MACHINERY** Is machinery present at this feature? Circle one. YES NO

a) Location of machinery. Check all that apply.

Inside Building [ ] No Building [ ] Outside Building [ ] Other (specify) [ ]

b) Type of machinery. Check all that apply or specify other.

| | | | | |
|---|---|---|---|---|
| Amalgamation Equipment [ ] | Crusher(s) [ ] | Ore Bin(s) [ ] | Stamp Mill(s) [ ] | Vat(s) [ ] |
| Arrastre [ ] | Flotation Cell Group [ ] | Retort(s) [ ] | Tank(s) [ ] | |
| Ball Mill(s) [ ] | Leach Tank(s) [ ] | Rod Mill(s) [ ] | Thickener(s) [ ] | |

Others (specify) [ ]

**17) PHOTOGRAPH NUMBERS** NONE

**18) SKETCH NUMBERS** NONE

COMMENTS

Water bed color represents bed color at portal.

U.S. Bureau of Mines

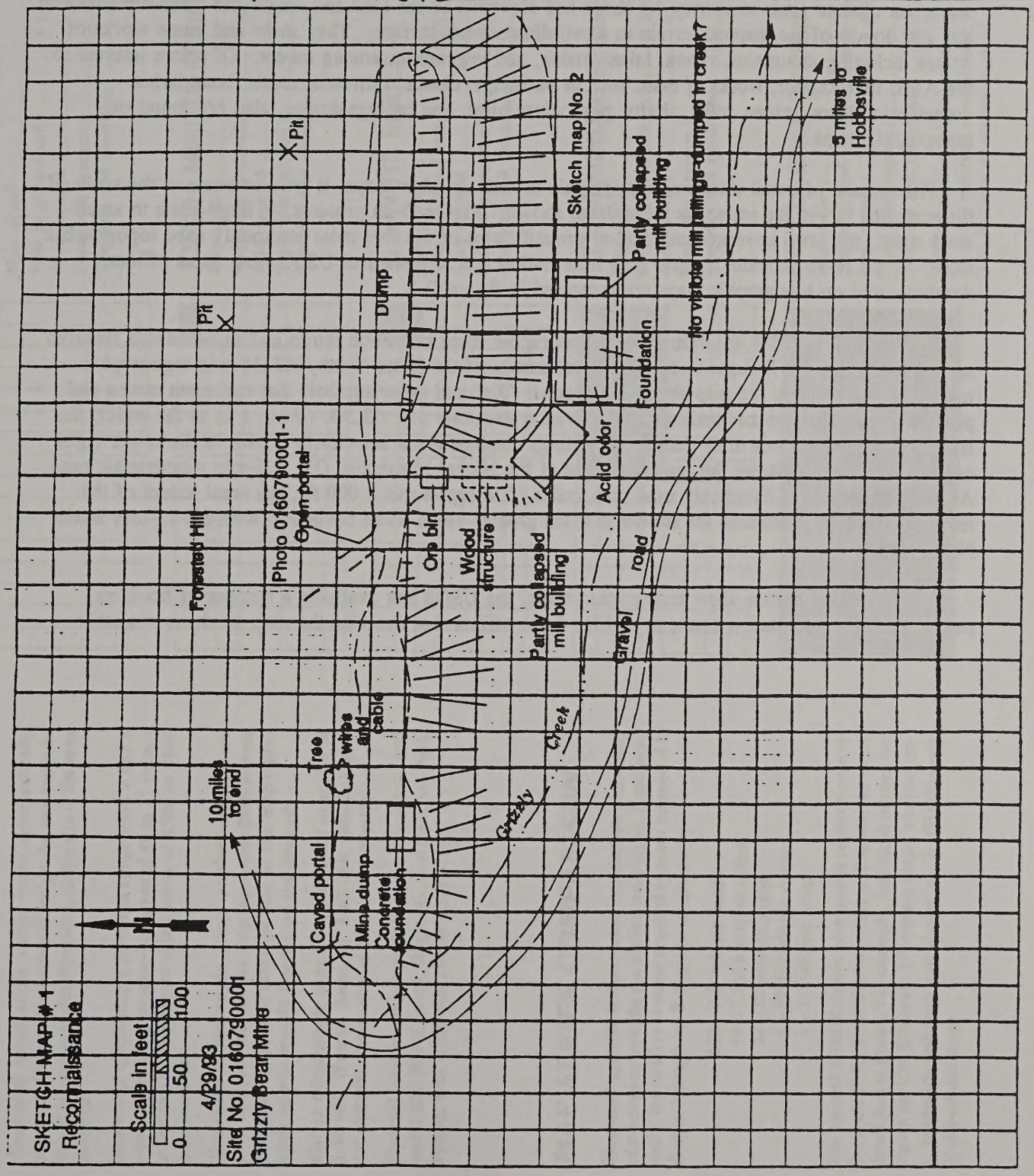
AML INVENTORY FORM

Part III - Supplemental Data (Notes, Sketches, Photographs, etc.)

PAGE 3 OF 3

SITE NUMBER 0160799203

DATE 4-28-93




NOTE. Be sure to provide a north arrow and the scale on sketch maps.

## APPENDIX D.–TOPOGRAPHIC MAPS

The distinctive feature of topographic maps with respect to other map types is that topographic maps use contour lines to portray the shape and elevation of the land and render the three-dimensional ups and downs of the mapped terrain to a two-dimensional surface. They show and name works of nature including mountains, rivers, lakes, plains, and vegetation, among others. Of prime interest to the AML investigator, works of man, such as buildings, canals, railroads, roads, boundaries, transmission lines, mines, mills, shafts, pits, waste piles, and tailings dumps, also are found on topographic maps.

The amount of detail shown on topographic as well as other maps, is proportionate to the scale of the map: the larger the scale, the more detail shown. Figure D-1a presents, in large-scale to small-scale order, the areal coverage and map-to-ground ratios of the five most commonly used topographic maps; figure D-1b provides general map information and addresses of USGS Map Sales offices. Symbols used on topographic maps are presented in figure D-2.

Figures D-3 and D-4 are examples of topographic maps on which mines and mine-related features are depicted. Figure D-3 shows the southwest corner of the Butte North, MT 15-min topographic map. As can be seen, the map shows many small "Xs" and other symbols that represent mines and prospects, both surface and underground. Even at the scale of 1:62,500 (about 1 in to the mile), the Berkeley Pit and various mine dumps and tailings disposal areas are clearly shown in the lower right corner. Figure D-4 shows the central portion of the Nickel Mountain, OR, 7.5-min topographic map. At this, the largest of commonly used map scales (1 in represents 2,000 ft), the areal extent of the mine and associated features are shown in much greater detail when compared with the 15-min Butte North map.

For more information about topographic maps, the USGS has available a number of booklets, pamphlets, and information sheets at its Map Sales offices that describe the map products available.

## STANDARD SERIES MAPS

*Standard quadrangle maps* cover systematically subdivided areas of latitude and longitude, and are published at various scales depending on the size of the area mapped

*Standard quadrangle formats* range from 7.5x7.5 minutes covering geographic areas of 49 to 71 square miles to 1x2 degrees covering areas of 4580 to 8669 square miles

*Standard quadrangle map scales* range from 1:24 000 (one inch on the map represents 2000 feet on the ground) to 1:250 000 (one inch on the map represents approximately 4 miles on the ground)

*Other quadrangle maps* are published at scales of 1:20 000 (Puerto Rico) to 1:63 360 (Alaska) and 1:1 000 000 (International Map of the World)

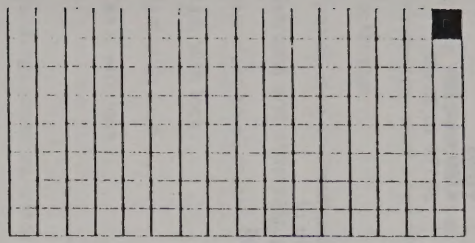
*Special area maps* are published at scales of 1:50 000 and 1:100 000 (County, Regional, and National Park Maps), and 1:500 000 (State Base Maps).

## MAP SERIES COMPARISON

Illustrated opposite is the relative comparison of the size of the area covered by the various map series. Comparatively, the number of maps required to cover an area of 1 degree latitude by 2 degrees longitude is:

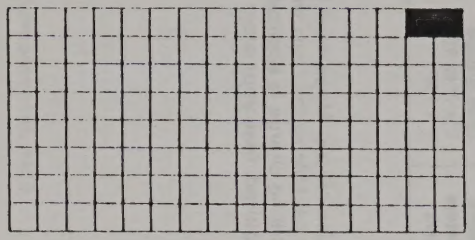
128—7.5 minute maps
64—7.5x15 minute maps
32—15 minute maps
4—30x60 minute maps
1—1x2 degree map

The amount of detail shown on a map is proportionate to the scale of the map; the larger the map scale, the more detail that is shown. For example, individual houses are shown on 1:24 000-scale 7.5-minute maps, whereas only landmark buildings are shown on 1:100 000-scale 30x60-minute maps.



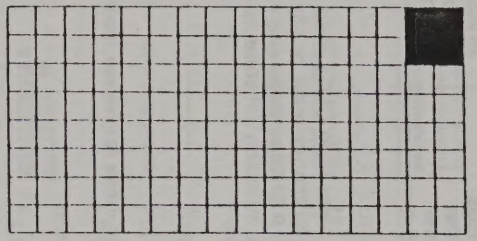
### 7.5 MINUTE SERIES

Map scale[1] ..... 1:24 000
Map to ground ratio ..... 1 inch represents 2000 feet
Area covered ..... 49 – 71 square miles
Paper size (approx.) ..... 22"x27"
Contours and elevations[2] ..... shown in feet



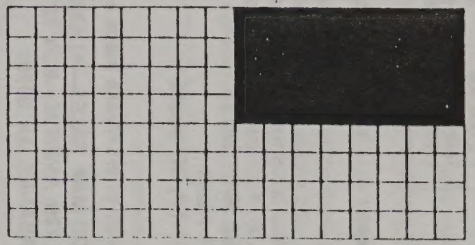
### 7.5 X 15 MINUTE SERIES

Map scale ..... 1:25 000
Map to ground ratio ..... 1 inch represents 2083 feet
Area covered ..... 100 – 140 square miles
Paper size (approx.) ..... 24"x40"
Contours and elevations ..... shown in meters



### 15 MINUTE SERIES

Map scale[3] ..... 1:62 500
Map to ground ratio ..... 1 inch represents about 1 mile
Area covered ..... 197 – 282 square miles
Paper size (approx.) ..... 18"x22"
Contours and elevations[2] ..... shown in feet



### 30 X 60 MINUTE SERIES

Map scale ..... 1:100 000
Map to ground ratio ..... 1 inch represents 1.6 miles
Area covered ..... 1578 – 2167 square miles
Paper size (approx.) ..... 29"x44"
Contours and elevations ..... shown in meters



### 1 X 2 DEGREE SERIES

Map scale ..... 1:250 000
Map to ground ratio ..... 1 inch represents about 4 miles
Area covered ..... 4580 – 8669 square miles
Paper size (approx.) ..... 22"x32"
Contours and elevations[2] ..... shown in feet

[1] 1:25 000 scale on selected maps
[2] Shown in meters on selected maps
[3] 1:50 000 scale on selected maps

Figure D-1a.—Information regarding five commonly-used topographic maps.

| Series | Scale | 1 inch represents approximately | 1 centimeter represents | Size (latitude x longitude) | Area (square miles) |
|---|---|---|---|---|---|
| Puerto Rico 7.5-minute | 1:20,000 | 1,667 feet | 200 meters | 7.5 x 7.5 min. | 71 |
| 7.5-minute | 1:24,000 | 2,000 feet (exact) | 240 meters | 7.5 x 7.5 min. | 49 to 70 |
| 7.5-minute | 1:25,000 | 2,083 feet | 250 meters | 7.5 x 7.5 min. | 49 to 70 |
| 7.5 x 15-minute | 1:25,000 | 2,083 feet | 250 meters | 7.5 x 15 min. | 98 to 140 |
| USGS DMA 15-minute | 1:50,000 | 4,166 feet | 500 meters | 15 x 15 min. | 197 to 282 |
| 15-minute | 1:62,500 | 1 mile | 625 meters | 15 x 15 min. | 197 to 282 |
| Alaska 1:63,360 | 1:63,360 | 1 mile (exact) | 633.6 meters | 15 x 20 to 36 min. | 207 to 281 |
| County 1:50,000 | 1:50,000 | 4,166 feet | 500 meters | County area | Varies |
| County 1:100,000 | 1:100,000 | 1.6 miles | 1 kilometer | County area | Varies |
| 30 x 60-minute | 1:100,000 | 1.6 miles | 1 kilometer | 30 x 60 min. | 1,568 to 2,240 |
| U. S. 1:250,000 | 1:250,000 | 4 miles | 2.5 kilometers | 1° x 2° or 3° | 4,580 to 8,669 |
| State maps | 1:500,000 | 8 miles | 5 kilometers | State area | Varies |
| U. S. 1:1,000,000 | 1:1,000,000 | 16 miles | 10 kilometers | 4° x 6° | 73,734 to 102,759 |
| U. S. Sectional | 1:2,000,000 | 32 miles | 20 kilometers | State groups | Varies |
| Antarctica 1:250,000 | 1:250,000 | 4 miles | 2.5 kilometers | 1° x 3° to 15° | 4,089 to 8,336 |
| Antarctica 1:500,000 | 1:500,000 | 8 miles | 5 kilometers | 2° x 7.5° | 28,174 to 30,462 |

### How to order maps and indexes

**Mail orders**: Free indexes may be ordered by State or index name from USGS map sales offices. Maps must be ordered by map name, State, and series/scale. Payment by money order or check payable to the Department of the Interior–USGS must accompany your order. A $1.00 postage and handling charge is applicable on orders less than $10.00. Your complete address, including ZIP code, is required. Mail your order and prepayment to: **USGS MAP SALES**
**BOX 25286**
**DENVER, CO 80225**

Residents of Alaska may order Alaska maps or an index for Alaska from:

**USGS MAP SALES—ALASKA**
**101 12th AVENUE—BOX 12**
**FAIRBANKS, AK 99701**

**Sales counters**: Maps of the area may be purchased over the counter at the following U.S. Geological Survey offices.

| | | |
|---|---|---|
| Alaska | Anchorage | Room 101, 4230 University Drive |
| | | E–146 Federal Building, 701 C Street |
| | Fairbanks | Room 126 New Federal Building, 101 12th Avenue |
| California | Los Angeles | Room 7638 Federal Building, 300 N. Los Angeles Street |
| | Menlo Park | Room 3128 Building 3, 345 Middlefield Road |
| | San Francisco | Room 504 Custom House, 555 Battery Street |
| Colorado | Denver | Building 810, Federal Center |
| | | Room 169 Federal Building, 1961 Stout Street |
| District of Columbia | Washington | Room 2650 Interior Building, 18th & C Street N.W. |
| Mississippi | S.S.C. | Building 3101, Stennis Space Center |
| Missouri | Rolla | 1400 Independence Road |
| Utah | Salt Lake City | Room 8105 Federal Building, 125 S. State Street |
| Virginia | Reston | Room 1C–402 National Center, 12201 Sunrise Valley Drive |
| Washington | Spokane | Room 678 U.S. Courthouse, West 920 Riverside Avenue |

**Commercial dealers**: Names and addresses of dealers are listed in your local yellow pages. Commercial dealers sell U.S. Geological Survey maps at their own prices.

**Figure D-1b.–General map information and USGS Map Sales offices.**

## Map Symbols

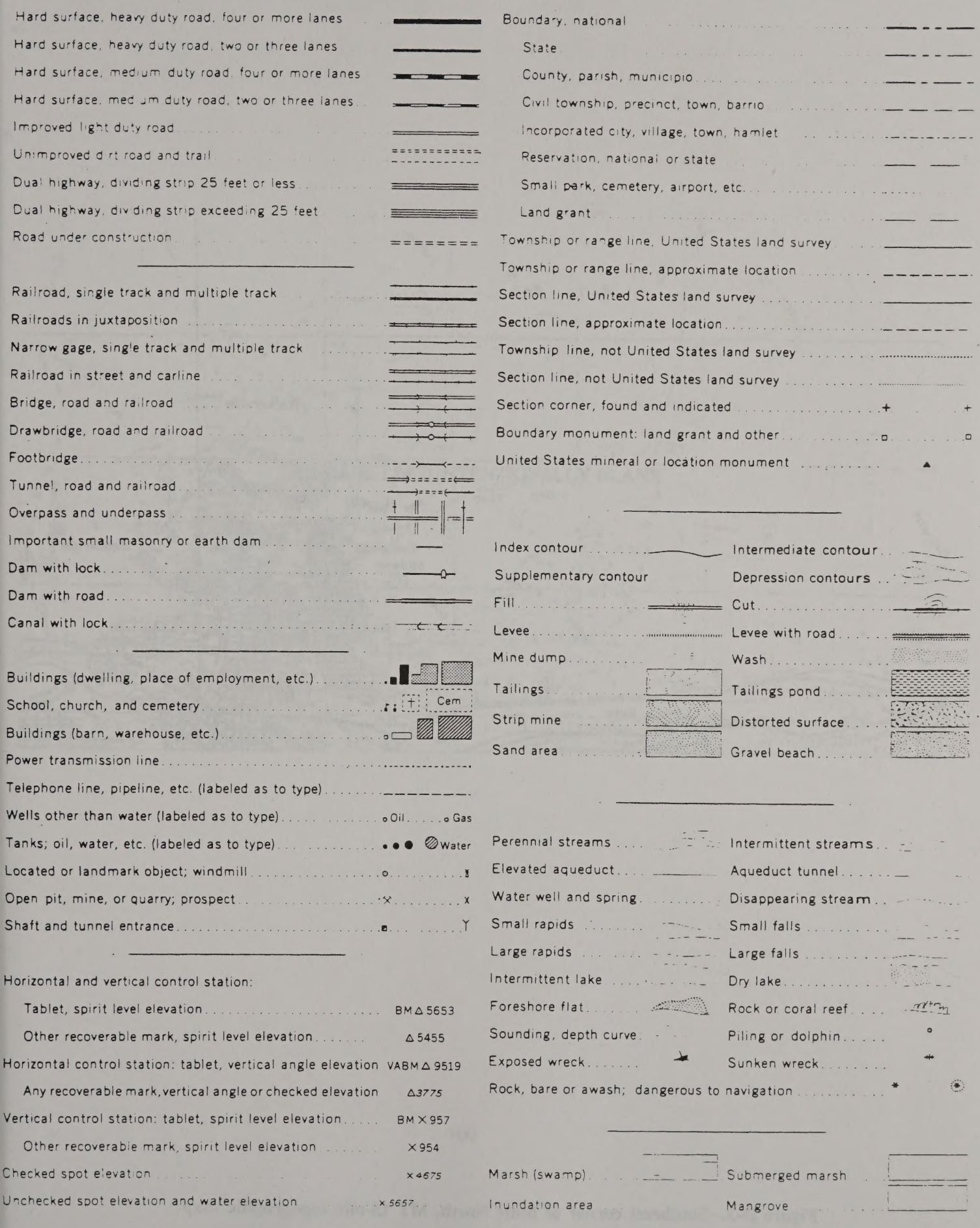



Figure D-2.--Topographic map symbols




**Figure D-3.–Southeast corner of Butte North, MT 15-min topographic map.**

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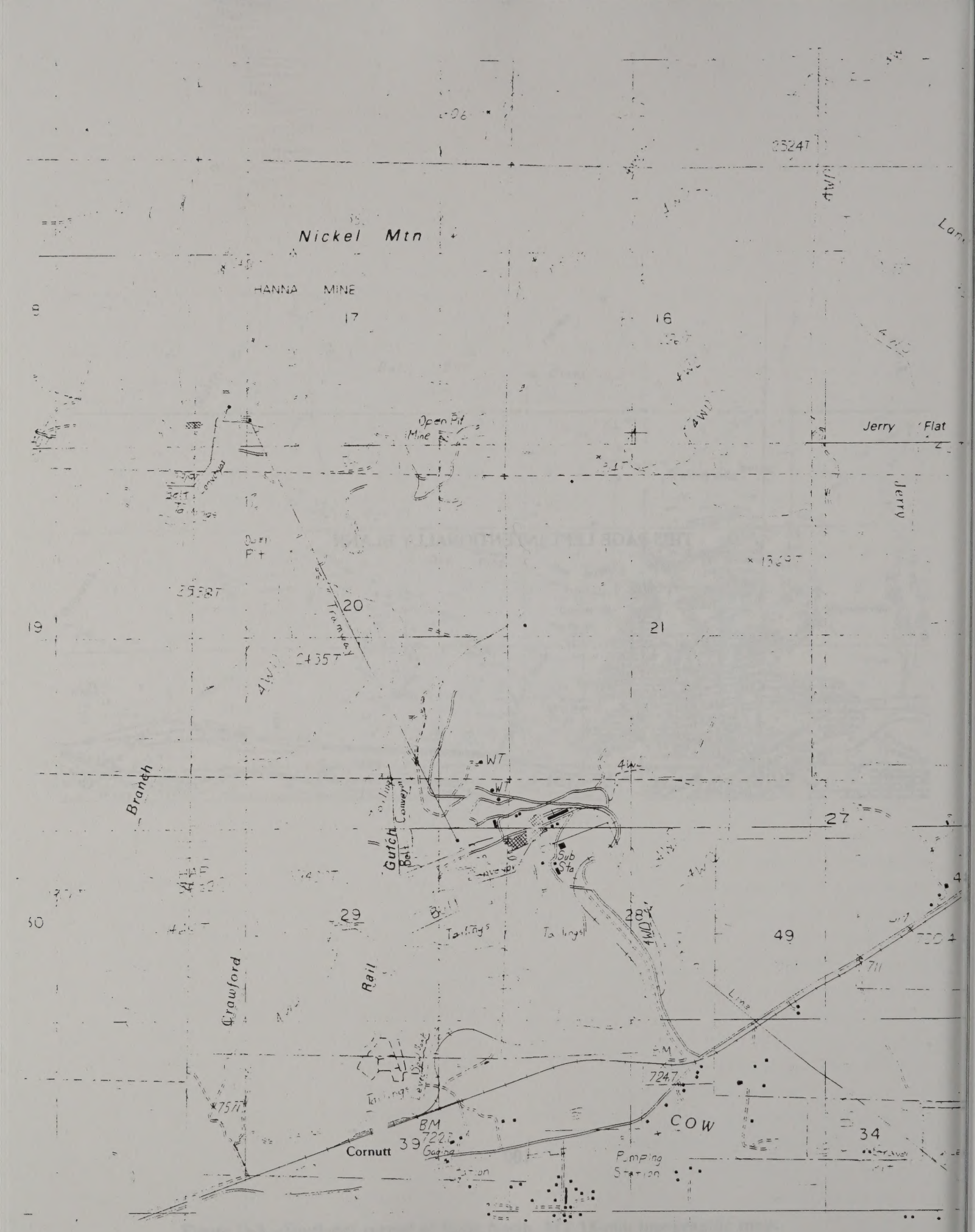



**Figure D-4.--Central portion of Nickel Mtn., OR 7-5 min topographic map.**

## APPENDIX E.–HAZARD RANKING TABLES

### Table E-1.–Hazard values for commodities and materials

| Commodity | Human | Environmental | Source |
|---|---|---|---|
| Abrasive | 0 | 0 | USBM[1] |
| Aluminum | 4 | 2 | DOD[2] |
| Antimony | 7 | 1 | DOD |
| Arsenic | 7 | 4 | DOD |
| Asbestos | 6 | 1 | DOD |
| Barium | 6 | 1 | DOD |
| Beryllium | 2 | 2 | USBM |
| Bismuth | 2 | 2 | USBM |
| Boron | 2 | 3 | DOD |
| Cadmium | 8 | 5 | DOD |
| Calcium | 0 | 0 | USBM |
| Cesium | 4 | 4 | DOD |
| Chromite | 7 | 4 | DOD |
| Chromium | 7 | 4 | DOD |
| Cinders | 0 | 0 | USBM |
| Clay | 0 | 0 | USBM |
| Coal | 0 | 0 | USBM |
| Cobalt | 8 | 2 | DOD |
| Columbium | 2 | 2 | USBM |
| Copper | 5 | 5 | DOD |
| Cyanide | 2 | 5 | DOD |
| Diatomite | 0 | 0 | USBM |
| Feldspar | 0 | 0 | USBM |
| Fluorine | 2 | 1 | DOD |
| Gallium | 2 | 2 | USBM |
| Gemstone | 0 | 0 | USBM |
| Geothermal | 2 | 2 | USBM |
| Gold | 2 | 2 | USBM |
| Graphite | 0 | 0 | USBM |
| Gypsum | 0 | 0 | USBM |
| Hafnium | 2 | 2 | USBM |
| Iridium | 2 | 2 | USBM |
| Iron | 4 | 2 | DOD |
| Kyanite | 0 | 0 | USBM |
| Kyanite Group | 0 | 0 | USBM |
| Lead | 8 | 5 | DOD |
| Manganese | 3 | 3 | USBM |
| Magnesium | 2 | 1 | DOD |
| Mercury | 9 | 6 | DOD |
| Mica | 0 | 0 | USBM |
| Molybdenum | 2 | 2 | USBM |
| Nickel | 7 | 5 | DOD |
| Niobium | 2 | 2 | USBM |
| Olivine | 0 | 0 | USBM |
| Osmium | 2 | 2 | USBM |

Table E-1.–Hazard values for commodities and materials–Continued

| Commodity | Human | Environmental | Source |
|---|---|---|---|
| Palladium | 2 | 2 | USBM |
| Peat | 0 | 0 | USBM |
| Perlite | 0 | 0 | USBM |
| Petroleum | 2 | 2 | USBM |
| Phosphate | 2 | 2 | USBM |
| Platinum | 2 | 2 | USBM |
| Platinum Group | 2 | 2 | USBM |
| Pumice | 0 | 0 | USBM |
| Quartz crystal | 0 | 0 | USBM |
| Radium | 3 | 1 | DOD |
| Rare Earth | 2 | 2 | USBM |
| Rhenium | 2 | 2 | USBM |
| Rhodium | 2 | 2 | USBM |
| Ruthenium | 2 | 2 | USBM |
| Sand and gravel | 0 | 0 | USBM |
| Selenium | 6 | 4 | DOD |
| Shale | 0 | 0 | USBM |
| Silica | 0 | 0 | USBM |
| Silicon | 0 | 0 | USBM |
| Silver | 5 | 6 | DOD |
| Sodium | 2 | 2 | DOD |
| Stone | 0 | 0 | USBM |
| Strontium | 3 | 1 | DOD |
| Sulfate | 2 | 2 | USBM |
| Sulfide | 2 | 2 | USBM |
| Sulfur | 2 | 2 | USBM |
| Talc | 0 | 0 | USBM |
| Tantalum | 2 | 2 | USBM |
| Tellurium | 2 | 2 | USBM |
| Thallium | 7 | 3 | DOD |
| Thorium | 2 | 2 | USBM |
| Tin | 2 | 2 | USBM |
| Titanium | 2 | 2 | USBM |
| Tungsten | 2 | 2 | USBM |
| Uranium | 4 | 1 | DOD |
| Vanadium | 4 | 3 | DOD |
| Zeolite | 0 | 0 | USBM |
| Zinc | 5 | 4 | DOD |
| Zirconium | 2 | 2 | USBM |
| (No data) | ERR | ERR | |

_ ERR Suggested for entry into a spreadsheet type software "lookup" to indicate that commodity was either not entered accidentally or commodity is not known.

[1]U.S. Bureau of Mines, WFOC, determined.

[2]U.S. Department of Defense, Priority Model report.

**Table E-2.–Status**

| Code | Factor |
|---|---|
| Past producer | 2 |
| Developed deposit | 1.5 |
| Explored prospect | 1.2 |
| Raw prospect | 1 |
| (No data) | ERR |

ERR Suggested for entry into a spreadsheet type software "lookup" to indicate status is not known.

**Table E-3.–Type (Property type)**

| Code | Factor |
|---|---|
| Surface | 1.2 |
| Underground | 1.2 |
| Surface-underground | 1.2 |
| Mineral location | 1 |
| Placer | 1 |
| Unknown | 1 |
| Well | 1 |
| Processing plant | 1 |
| (No data)[1] | 1 |

[1]For no data, suggest default equal factor of "1."

**Table E-4.–Size**

| Production, total mt based on size | Factor |
|---|---|
| Very small, < 1,000 | < 1 |
| Small, 1,000-10,000 | 1.2 |
| Small-Medium, > 10,000-250,000 | 1.4 |
| Medium, > 250,000-500,000 | 1.6 |
| Medium-Large, > 500,000 to 1 million | 1.8 |
| Large, > 1 million | 2 |
| (No data)[1] | 1 |

[1]For no data, suggest default equal factor of "1."

**Table E-5.–Mill type**

| Code | Factor |
|---|---|
| Amalgamation | 2.2 |
| Arrastre | 1.2 |
| CIP | 2.2 |
| Crusher (only) | 1 |
| Cyanidation | 2.2 |
| Flotation | 2.2 |
| Gravity | 1.6 |
| Heap leach | 2.2 |
| Jig plant | 1.6 |
| Leach | 2.2 |
| Retort | 2.2 |
| Stamp | 1.6 |
| Unknown/Possible | 2 |
| (No mill) | 1 |

[1]When no indication of the presence of a mill, use default factor value equal to "1."

**Table E-6.–Acid potential**

| Code | Factor |
|---|---|
| Yes | 1.2 |
| No | 1 |

**Table E-7.–Acid producers or indicator minerals**

Arsenopyrite
Chalcopyrite
Galena
Iron oxide
Limonite
Marcasite
Pyrrhotite
Pyrite[1]
Sphalerite
Sulfide
Sulfur (elemental)

[1]Pyrite is the principal "acid producing" mineral. The other minerals are indicators for possible presence of pyrite.

**Table E-8.–Neutralizing host rocks**

Carbonate
Dolomite
Limestone
Marble

## APPENDIX F.– HOW AND WHERE TO ACQUIRE MILS AND OTHER BUREAU OF MINES DATA

MILS and other Bureau of Mines data may be obtained by contacting the following Bureau Field Operations Centers:

For the State of Alaska: Alaska Field Operations Center, 3301 C Street, Suite 525, Anchorage, AK, 99503-3935, Information No. (907) 271-2455, Facsimile No. (907) 271-3933.

For the States of California, Hawaii, Idaho, Montana, Nevada, Oregon, and Washington: Western Field Operations Center, E. 360 Third Avenue, Spokane, WA, 99204-1413, Information No. (509) 353-2700, Facsimile No. (509) 353-2661.

All other States: Intermountain Field Operations Center, P.O. Box 25086, Building 20, Denver Federal Center, Denver, CO, 80225, Information No. (303) 236-0421, Facsimile No. (303) 236-0238.

A request for MILS data should include the following:

(1) A list of all topographic maps using the exact map name as it appears in the lower right corner of the map.

(2) Next to the name, note the latitude and longitude coordinates of the lower right and upper left corners of the map. For example:

| Map Name | Lower lat/lon | Upperlat/lon |
|---|---|---|
| Butte North, MT | 46°00'/112°30' | 46°15'/112°45' |

(3) Specify a "Nonconfidential MILS Listing" of all properties within the areas specified.

The USBM will provide literature reviews, data gathering, hazard ranking, on-site investigations, and site characterization on a reimbursable basis. For more information, contact the Western Field Operations Center, Spokane, WA at (509) 353-2700.

## APPENDIX G.–SUGGESTED SAFETY TRAINING FOR ABANDONED MINE SITE INVESTIGATORS

The following is a summary of the training that may be required for site investigators. The actual training requirements will vary and depend on a number of factors, including climate, topography, the remoteness of the site(s), and agency requirements.

I. Personal Safety and Survival

a. First aid

b. Adult cardio-pulmonary resuscitation (CPR)

c. Wild animal safety; habits, methods of avoiding encounters.

d. Outdoor survival; basics of how to stay healthy while working outdoors and, in an emergency, how to survive until help arrives.

e. Mine safety training; required for all personnel who work in active mines. The course is taught by instructors who have been trained and certified by the Mine Safety and Health Administration (MSHA), U.S. Department of Labor. Although this course emphasizes active mining, many of the instructors have experience with abandoned mines and might be able to offer helpful advice.

II. Transportation

a. Helicopter safety; proper methods of approaching, entering, and exiting helicopters. Also, loading equipment inside or outside of helicopter.

b. Helicopter slinging procedures; proper rigging, slinging, and releasing loads. Also, avoiding electrocution by static electricity.

c. Defensive and off-road driving; anticipating and avoiding motor vehicle accidents on highway and off.

III. Hazardous Materials

a. Hazardous materials site worker; Environmental Protection Agency (EPA) approved, 40-h course on identifying hazardous materials, handling them correctly, and using personal protection equipment. This course will provide certification after successful completion. An 8-h refresher course must be taken each year afterward to maintain certification. *This training, while recommended, may not be necessary in all cases or for all workers.*

b. Hazardous materials operations supervisor; EPA-approved 24-h course on organizing work teams, maintaining safety discipline, and managing decontamination operations. *As above, this training is recommended but may not be necessary in all cases or for all workers.*

c. Hazardous materials awareness; general overview of recognizing hazardous materials in the field, maintaining personal safety, and reporting information to authorities.

d. Abandoned explosives; identifying the various types of explosives and related items, maintaining personal safety, and reporting information to authorities.

IV. Administration

a. Administrative procedures, including contacting the home office regularly, summoning help in an emergency, and notifying proper supervisory personnel in an emergency.

b. Communications; operating personal and base-station radios; knowing operational and emergency frequencies.

c. Camp operations; disseminating information on camp organization, responsibilities, hygiene, and resupply.

## APPENDIX G.–SUGGESTED SAFETY TRAINING FOR ABANDONED MINE SITE INVESTIGATORS

The following is a summary of the training that may be required for site investigators. The actual training requirements will vary and depend on a number of factors, including climate, topography, the remoteness of the site(s), and agency requirements.

I. Personal Safety and Survival

a. First aid

b. Adult cardio-pulmonary resuscitation (CPR)

c. Wild animal safety; habits, methods of avoiding encounters.

d. Outdoor survival; basics of how to stay healthy while working outdoors and, in an emergency, how to survive until help arrives.

e. Mine safety training; required for all personnel who work in active mines. The course is taught by instructors who have been trained and certified by the Mine Safety and Health Administration (MSHA), U.S. Department of Labor. Although this course emphasizes active mining, many of the instructors have experience with abandoned mines and might be able to offer helpful advice.

II. Transportation

a. Helicopter safety; proper methods of approaching, entering, and exiting helicopters. Also, loading equipment inside or outside of helicopter.

b. Helicopter slinging procedures; proper rigging, slinging, and releasing loads. Also, avoiding electrocution by static electricity.

c. Defensive and off-road driving; anticipating and avoiding motor vehicle accidents on highway and off.

III. Hazardous Materials

a. Hazardous materials site worker; Environmental Protection Agency (EPA) approved, 40-h course on identifying hazardous materials, handling them correctly, and using personal protection equipment. This course will provide certification after successful completion. An 8-h refresher course must be taken each year afterward to maintain certification. *This training, while recommended, may not be necessary in all cases or for all workers.*

b. Hazardous materials operations supervisor; EPA-approved 24-h course on organizing work teams, maintaining safety discipline, and managing decontamination operations. *As above, this training is recommended but may not be necessary in all cases or for all workers.*

II. Other field equipment

a. Team survival kit containing sleeping bags, small tent, freeze-dried food, water-proof matches, flares, fuel-tablet stove, fuel tablets, and wire
b. Shovel
c. Pickax
d. Tape measure, 30 m (100 ft) long
e. Plastic flagging of any bright color
f. Marking pens
g. Tape measure, 3 m (10 ft) long
h. Rope, 13-mm- (1/2-in) diam and 30 m (100 ft) long
i. Rope climbers for above rope
j. Ranch jack
k. Gasoline can with spout
l. Assorted mechanic's tools
m. Machete
n. Bow saw
o. Sampling equipment (sample bags, canvas bags, vials of various capacities, waterproof adhesive tape, sample books, etc.)

III. Analytical supplies and other equipment

a. Portable pH meter, or pH indicator (litmus) paper
b. Geiger counter or scintillometer
c. Portable conductivity meter
d. Global positioning system (GPS) receiver

## APPENDIX H.–SUGGESTED EQUIPMENT AND SUPPLIES

The following is a **suggested** list of safety equipment and supplies for use in conducting AML site investigations. **Actual** requirements will vary depending on, among others, climate, weather, season, region of operations, and agency policy.

I. Personal equipment

a. Safety equipment

1. Hard hat
2. Safety glasses
3. Ear plugs
4. Steel-toed boots
5. Leather gloves
6. Personal first aid kit
7. Personal survival kit
8. Fireproof shirt (for aircraft use)
9. Fireproof trousers (for aircraft use)
10. Flight helmet (for aircraft use)
11. Fireproof gloves (for aircraft use)
12. Head lamp (**if underground operations are considered necessary**)
13. Portable radio
14. Firearm if location warrants (.44 magnum pistol or 12-gauge shotgun for bears–primarily in Alaska and Montana)
15. Ammunition (.44 magnum pistol with 300-grain hard lead bullets or 12-gauge sabot shells–primarily in Alaska and Montana)
16. Bear repellent spray–primarily in Alaska and Montana

b. Other equipment

1. Completed pre-field forms
2. Field forms
3. Maps
4. Compass
5. Field notebook
6. Pencils, pens, scale, protractor
7. Altimeter
8. Backpack
9. Flashlight with extra batteries
10. Mosquito headnet (primarily in Alaska)
11. Wool shirt
12. Equipment vest
13. Raincoat and trousers
14. Rock hammer
15. Canteen(s) of water
16. Camera with extra film
17. Hiking socks

## APPENDIX I.–AML FEATURES, OBSERVATIONS, HAZARDS, AND ACTIONS–Continued

| Feature | Observation | Potential hazard | Action |
|---|---|---|---|
| | Explosives and/or suplies | Physical hazard | Photograph, note occurrence |
| Vertical or inclined; glory hole | Open to entry | do. | Photograph; measure |
| | Partly caved | do. | do. |
| | Caved | do. | Note condition |
| | Water filled; yellow-orange stain | do. | do. |
| | | AMD, heavy metals | Photograph; pH, conductivity |
| | Flowing water; yellow-orange stain; presence of filamentous algae | AMD, heavy metal transport | do. |
| | Uranium mining area | Radiation | Photograph; note possibility of radiation hazard |
| | Stains (yellow-orange or dark gray to black) on rock or soil | Indicates possible AMD, heavy metals, chemical or petroleum product spill | Photograph, note color and location; sketch map may be appropriate; if water is present, check pH, conductivity |
| | Acrid odor | Acid development, heavy metal transport, chemical or petroleum spill | Note presence and approximate location, estimate size |
| | Thin ground over workings | Physical hazard | Photograph; note location |
| | Animals inhabit workings | do. | Note occurrence |

## APPENDIX I.–AML FEATURES, OBSERVATIONS, HAZARDS, AND ACTIONS–Continued

| Feature | Observation | Potential hazard | Action |
|---|---|---|---|
| | Guano (bat manure) | Physical hazard, disease | Note occurrence |
| | Explosives and/or supplies | Physical hazard | do. |
| Small pit or trench | Open to entry | Minor hazard | Photograph; measure |
| | Closed to entry | do. | do. |
| Large pit or quarry | Open to entry | Physical hazard | Photograph; estimate size |
| | Partly caved, unstable walls | do. | do. |
| | Water filled (part or all); yellow-orange stain | AMD, heavy metal transport | Photograph; estimate size; pH, conductivity |
| | Flowing water; yellow-orange stain, filamentous algae | do. | do. |
| | Stains (orange-yellow to dark gray-black | Heavy metal contamination; chemical or petroleum spill | Photograph; estimate area affected |
| | Uranium mining area | Radiation | Photograph; note possibility of radiation hazard |
| | Cribbed embankments | Physical hazards | Photograph; note presence, approximate size, and location |
| | Highwalls | do. | do. |
| | Unstable slopes | do. | do. |

## APPENDIX I.–AML FEATURES, OBSERVATIONS, HAZARDS, AND ACTIONS–Continued

| Feature | Observation | Potential hazard | Action |
|---|---|---|---|
| | Acrid odor | Acid development, heavy metal transport, chemical or petroleum spill | Note presence and approximate location |
| | Stains (yellow-orange or dark gray to black) on rock or soil | Indicates possible AMD, heavy metals, chemical or petroleum product spill | Photograph, note color and location; sketch map may be appropriate; if water is present, check pH, conductivity |
| Solution mining well | Subsidence | Physical hazard | Photograph; measure size |
| | Stains (orange-yellow to dark gray-black | Heavy metal contamination; chemical or petroleum spill | Photograph; estimate area affected |
| | Stains (yellow-orange or dark gray to black) on rock or soil | Indicates possible AMD, heavy metals, chemical or petroleum product spill | Photograph, note color and location; sketch map may be appropriate; if water is present, check pH, conductivity |
| Mine Infrastructure | | | |
| Buildings | Standing | Physical hazard | Photograph |
| Machinery | Stained ground | Chemical or petroleum spill | Photograph; note size and location |
| | Explosives shed | Physical hazard | Photograph; note location |
| | Outside a building | do. | do. |
| | Inside a building | do. | Photograph |

## APPENDIX I.–AML FEATURES, OBSERVATIONS, HAZARDS, AND ACTIONS–Continued

| Feature | Observation | Potential hazard | Action |
|---|---|---|---|
| | Stains (yellow-orange stain, or dark gray to black) on rock or soil | Indicates possible AMD, heavy metals, chemical or petroleum product spill | Photograph, note color and location; sketch map may be appropriate; if water is present, check pH, conductivity |
| Headframes | Standing | Physical hazard | Photograph |
| | Collapsed | do. | do. |
| | Cables | do. | Photograph; note location |
| Power substations | Transformers | PCB | Photograph; note number and approximate size |
| | Poles/wires | Physical hazard | Photograph; note location |
| Sumps and cisterns | Open or partly open tanks | do. | Photograph; note condition and location |
| Impoundments | Dams used to collect water | do. | do. |
| Mine Dumps | Scrap metal | do. | Photograph |
| | Refuse | Physical hazard, disease | Photograph; note location |
| | | Chemicals | Photograph; note location for further action |

## APPENDIX I.–AML FEATURES, OBSERVATIONS, HAZARDS, AND ACTIONS–Continued

| Feature | Observation | Potential hazard | Action |
|---|---|---|---|
| | Stains (yellow-orange or dark gray to black) on rock or soil | Indicates possible AMD, heavy metals, chemical or petroleum product spill | Photograph, note color and location; sketch map may be appropriate; if water is present, check pH, conductivity |
| | General size | Environmental hazard (potential heavy metals) | Data will be needed to determine relative significance |
| | Slope face erosion and undercutting | Physical hazard | Photograph |
| | | Sedimentation, heavy metal transport | Photograph, note color of exposed portion of dump; note erosion into water |
| | Stressed plants | Heavy metals, chemicals or petroleum contamination | Photograph; note color, location and size of affected area |
| | Radical change in vegetation density | do. | do. |
| | Lack of vegetation | Wind blown dust, acid generation, heavy metals transport | Photograph; estimate size of barren area |
| | Erosion | Sedimentation, heavy metals transport | Photograph; estimate size of eroded area |
| | Unstable sides; rotten cribbing | Physical hazard, Sedimentation, potential erosion and heavy metals transport | Photograph; estimate size of affected area |
| | Standing water | Acid generation, heavy metals | Photograph, note color, check pH, conductivity |

## APPENDIX I.–AML FEATURES, OBSERVATIONS, HAZARDS, AND ACTIONS–Continued

| Feature | Observation | Potential hazard | Action |
|---|---|---|---|
| | Water running from side or base of dump, filamentous algae | Acid generation, heavy metals transport, erosion and sedimentation | Photograph, note color; check pH, conductivity, note presence of filamentous algae |
| | Water running along or near base of dump | do. | Photograph; look for signs of erosion especially during periods of high runoff; note filamentous algae, presence of caddis fly cases |
| | Uranium mining area | Radiation | Photograph; note possibility of radiation hazard |
| | Stains (yellow-orange or dark gray to black) on rock or soil | Indicates possible AMD, heavy metals, chemical or petroleum product spill | Photograph, note color and location; sketch map may be appropriate; if water is present, check pH, conductivity |
| | Acrid odor | Heavy metals, chemicals, petroleum | Note presence and approximate location |
| | Buildings <<see buildings discussed above>> | | |
| Mine Ore Stockpiles | Piles of ore | Acid generation, heavy metals | Photograph; estimate size |
| | Ore bin-empty | Physical hazard | Photograph; note location |
| | Ore bin-full or contains some ore | do. | do. |

## APPENDIX I.–AML FEATURES, OBSERVATIONS, HAZARDS, AND ACTIONS–Continued

| Feature | Observation | Potential hazard | Action |
|---|---|---|---|
| | Ore bin-full or contains some ore | Acid generation, heavy metals | Photograph; note location |
| | Uranium mining area | Radiation | Photograph; note possibility of radiation hazard |
| | Stains (yellow-orange stain, or dark gray to black) on rock or soil | Indicates possible AMD, heavy metals, chemical or petroleum product spill | Photograph, note color and location; sketch map may be appropriate; if water is present, check pH, conductivity |
| | Acrid odor | Heavy metals, chemicals, petroleum | Note presence and approximate location |
| Raised Systems | | | |
| Flumes | Standing | Physical hazard | Photograph; note location |
| | Partly standing | do. | do. |
| | Collapsed | do. | do. |
| Trestles | Standing | do. | do. |
| | Partly standing | do. | do. |
| | Collapsed | do. | do. |
| Mill Infrastructure | | | |
| Building | | | |
| | Standing | Physical hazard; asbestos, chemicals | Photograph |
| | Partly collapsed | do. | do. |

## APPENDIX I.–AML FEATURES, OBSERVATIONS, HAZARDS, AND ACTIONS–Continued

| Feature | Observation | Potential hazard | Action |
|---|---|---|---|
| | Collapsed | Physical hazard; asbestos, chemicals | Photograph |
| | Stains (yellow-orange or dark gray to black) on rock or soil | Indicates possible AMD, heavy metals, chemical or petroleum product spill | Photograph, note color and location; sketch map may be appropriate; if water is present, check pH, conductivity |
| | Drums and/or bags | Chemicals | Photograph; note number and location |
| Machinery | Ball or rod mill | Physical hazard | Photograph |
| | | Mercury, cyanide, other chemicals, heavy metals | Note for future testing for mercury and cyanide |
| | Flotation cells | Physical hazard | Photograph |
| | | Chemicals | Note for future testing for flotation reagents |
| | Retort | Mercury | Note for future testing for mercury |
| | Leach tanks | Cyanide | Note for further testing for chemicals including cyanide |
| | Stamp Mill | Mercury | Photograph and note for further investigation for chemicals |
| | Amalgamation equipment | do. | do. |
| | Arrastre | do. | do. |

## APPENDIX I.–AML FEATURES, OBSERVATIONS, HAZARDS, AND ACTIONS–Continued

| Feature | Observation | Potential hazard | Action |
|---|---|---|---|
| | Concentrator ore bins | Heavy metals, acid generation | Photograph and note for further investigation for chemicals |
| | Tanks | Chemicals, residual fuels, cyanide, mercury | do. |
| | Thickeners | Cyanide, other chemicals | do. |
| | Vats | do. | Photograph and note for further investigation for chemicals |
| | Other equipment | Physical hazard | Photograph |
| | Yellow-orange to dark gray or black stains | Acid generation, heavy metals, chemicals, petroleum spill | Photograph; note size and location of affected area for future testing |
| | Uranium mining area | Radiation | Photograph; note possibility of radiation hazard |
| | Stains (yellow-orange or dark gray to black) on rock or soil | Indicates possible AMD, heavy metals, chemical or petroleum product spill | Photograph, note color and location; sketch map may be appropriate; if water is present, check pH, conductivity |
| | Acrid odor | Heavy metals, chemicals, petroleum | Note presence and approximate location |
| Power substations | Transformers | Environmental hazard | Photograph; note number and approximate size |
| | Poles/wires | Physical hazard | Photograph |

## APPENDIX I.–AML FEATURES, OBSERVATIONS, HAZARDS, AND ACTIONS–Continued

| Feature | Observation | Potential hazard | Action |
|---|---|---|---|
| Impoundments | Dams (usually with dry or nearly dry basins behind them) | Physical hazard | Photograph; note location and size and condition of dam |
| Mill Tailings (confined or unconfined) | Scrap metal | do. | Photograph |
| | Refuse | Physical hazard, disease | Photograph; note for further action |
| | | Chemicals | do. |
| | Yellow-orange to dark gray-black stains | Heavy metals, acid generation, chemical or petroleum spills | Photograph; note color and locations; sketch map may be appropriate |
| | General size | Heavy metals | Data will be needed to determine relative significance |
| | Confined or unconfined | Erosion, sedimentation, blowing dust | Photograph; note area and extent |
| | Dams (presence, integrity) | do. | Photograph; note any problems such as a breach, apparent erosion by a water body |
| | Slope face erosion and undercutting | Physical hazard | Photograph; measure size |
| | | Erosion and sedimentation | Photograph; note color of exposed portion of dump; note erosion into water and area affected |

## APPENDIX I.–AML FEATURES, OBSERVATIONS, HAZARDS, AND ACTIONS–Continued

| Feature | Observation | Potential hazard | Action |
|---|---|---|---|
| | Standing water | Possible acid generation, heavy metals | Photograph; note color, check pH, conductivity |
| | Water running from side or base of tailings; filamentous algae | do. | do. |
| | Water running along side or base of tailings, filamentous algae | Possible acid generation, heavy metals, possible erosion and sedimentation | do. |
| | Stressed vegetation | Possible heavy metal or chemical contamination, acid generation | Photograph; estimate size of area affected |
| | Radical change in vegetation density | Acid generation, heavy metals, chemical or petroleum spill | Note presence, approximate size of affected area |
| | Lack of vegetation | Windblown dust, acid generation, heavy metal transport | Photograph; estimate size of affected area |
| | Erosion | Sedimentation, transport of heavy metal-bearing material | do. |
| | Drums and/or bags | Physical hazard | Photograph; note location |
| | | Chemicals | Photograph; note location, number and labels |

## APPENDIX I.–AML FEATURES, OBSERVATIONS, HAZARDS, AND ACTIONS–Continued

| Feature | Observation | Potential hazard | Action |
|---|---|---|---|
| | Pipe (part of tailings or chemical distribution system) | Physical hazard | Photograph; note location |
| | | Chemicals | do. |
| | Uranium mining area | Radiation | Photograph; note possibility of radiation hazard |
| | Stains (yellow-orange or dark gray to black) on rock or soil | Indicates possible AMD, heavy metals, chemical or petroleum product spill | Photograph, note color and location; sketch map may be appropriate; if water is present, check pH, conductivity |
| | Acrid odor | Heavy metals, chemicals, petroleum | Note presence and approximate location |
| Leach Pads | General size | Heavy metals, chemicals | Photograph; note location and size |
| | Pipes and other equipment | Physical hazard | Photograph; note quantity and location |
| | | Chemicals | do. |
| | Drums, bags, etc | do. | Photograph; note location, number and labels |
| | Standing water | Acid generation, heavy metals | Photograph; note color; check pH, conductivity |
| | Water flowing from pad; filamentous algae | AMD, heavy metals | do. |

## APPENDIX I.–AML FEATURES, OBSERVATIONS, HAZARDS, AND ACTIONS–Continued

| Feature | Observation | Potential hazard | Action |
|---|---|---|---|
| | Proximity to bodies of water | AMD, heavy metals, sediment-ation | Photograph; note whether water body is or has eroded pile; stains |
| | Yellow-orange stains | AMD, heavy metals | Photograph; note location and extent |
| | Uranium mining area | Radiation | Photograph; note possibility of radiation hazard |
| | Stains (yellow-orange or dark gray to black) on rock or soil | Indicates possible AMD, heavy metals, chemical or petroleum product spill | Photograph, note color and location; sketch map may be appropriate; if water is present, check pH, conductivity |
| | Acrid odor | Heavy metals, chemicals, petroleum | Note presence and approximate location |
| Solution Ponds | Size | Heavy metals, chemicals, blowing dust | Photograph; note location and size |
| | Pipes and other equipment | Physical hazard | Photograph; note quantity and location |
| | | Chemicals | do. |
| | Drums, bags, etc | do. | Photograph; note location, number and labels |
| | Standing water | Acid generation, heavy metals | Photograph; note color; check pH, conductivity |
| | Water flowing from pad, filamentous algae | AMD, heavy metals, chemicals | do. |

## APPENDIX I.–AML FEATURES, OBSERVATIONS, HAZARDS, AND ACTIONS–Continued

| Feature | Observation | Potential hazard | Action |
|---|---|---|---|
| | Proximity of bodies of water | AMD, heavy metals, sediment-ation | Photograph; note whether water body is or has eroded pile |
| | Yellow-orange stains | AMD, heavy metals | Photograph; note location and extent |
| | Uranium mining area | Radiation | Photograph; note possibility of radiation hazard |
| | Stains (yellow-orange or dark gray to black) on rock or soil | Indicates possible AMD, heavy metals, chemical or petroleum product spill | Photograph, note color and location; sketch map may be appropriate; if water is present, check pH, conductivity |
| | Acrid odor | Heavy metals, chemicals, petroleum | Note presence and approximate location |
| Suspended Systems | | | |
| | Antennae (thin wires strung from trees or poles) | Physical hazards | Photograph; note location and prepare a sketch map |
| | Cables | do. | do. |
| | Power lines | do. | do. |
| | Tramways, buckets, and poles | do. | do. |
| | Wires | do. | do. |

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